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SFRSM Implementation and Application

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&

SFRSM Implementation Team

Introduction

- Address peer review goals related to implementation and application
- Calibration approach for RSM application to South Florida
- Show implementation and application tools

Peer Review Goal 3 :

Determine the appropriate use of the model in south Florida conditions

- Appropriate use
- Early RSM Applications
- SFRSM application
  - Specific peer review comments
- NSRSM application

Peer Review Goal 8 :

Evaluate whether the model is suitable for meeting client goals

- Client expectation management
- Client expectations
- Tools to meet client needs

Appropriate Use

Conditions for appropriate use

- Theoretically sound model
- Correct conceptualization and application
- Appropriate assumptions
- Good calibration/verification
- Stable reasonable simulation results outside of calibration conditions

Early RSM Applications

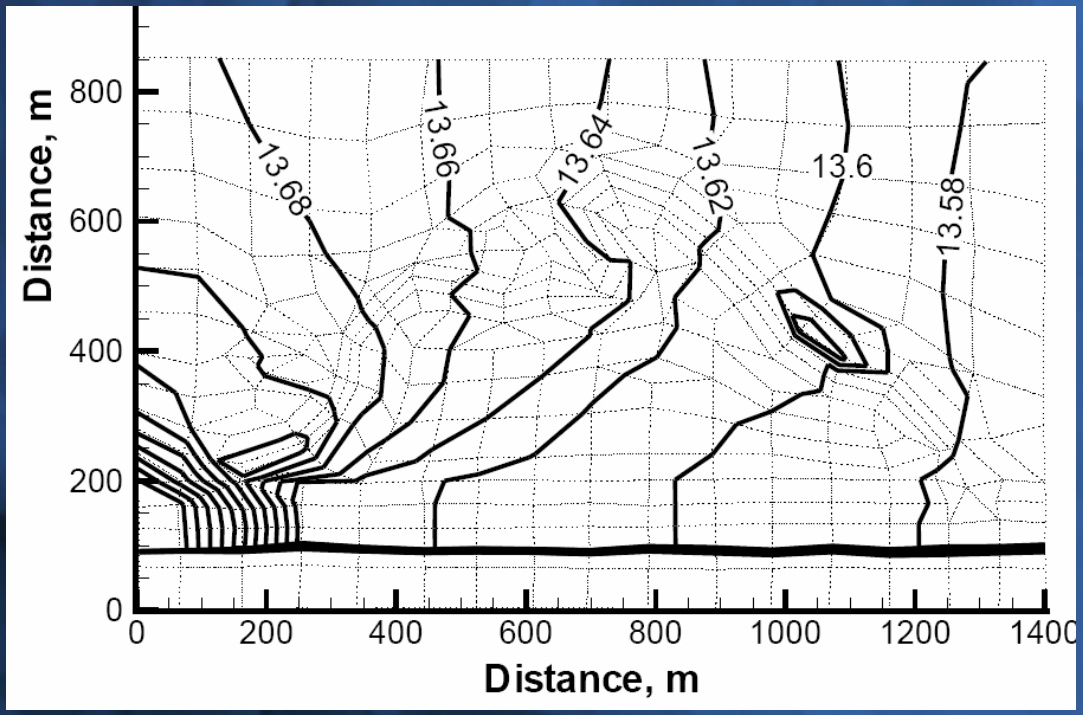
- Kissimmee Basin
- Everglades National Park
- L8 Drainage Basin
- Loxahatchee National Wildlife Reserve (WCA 1)
- Southwest Florida
- North Palm Beach County Pre-drainage
- Southern Everglades

Through these applications improved model concepts, features and improved robustness

Model is still in a state of development and improvement

Early RSM Applications highlights & lessons

Kissimmee Basin



- Proof of Concept
- 2D overland flow
- Demonstration of speed of solution

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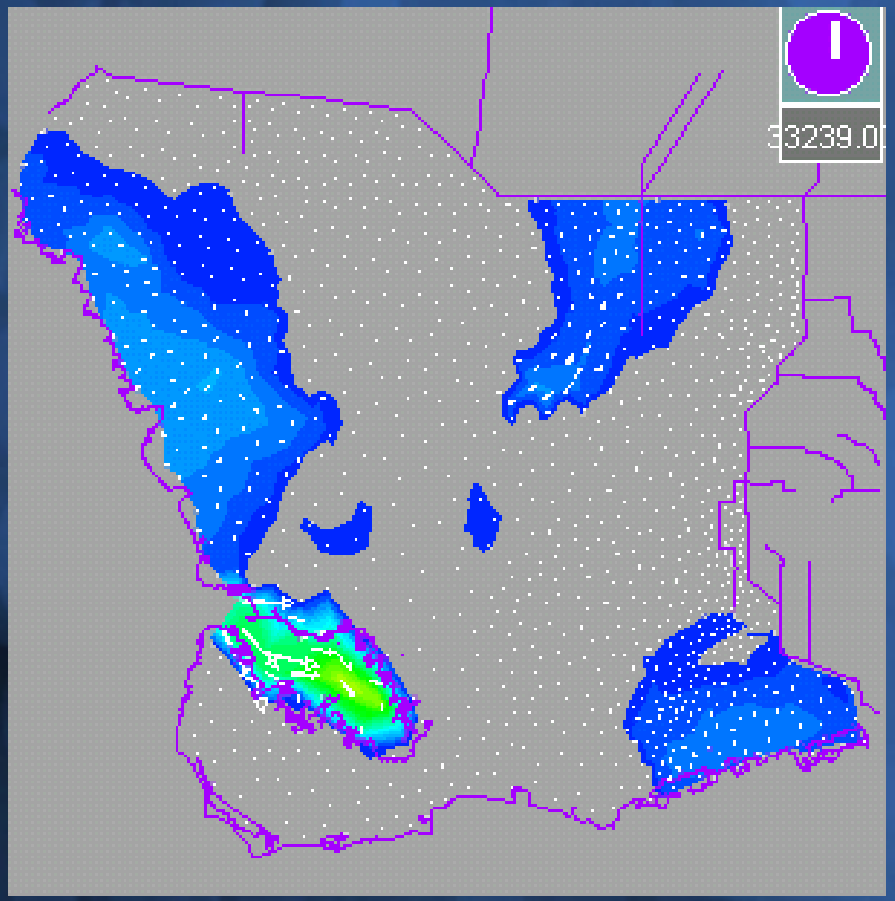
Early RSM Applications highlights & lessons

Everglades National Park



- 2D overland and groundwater interaction
- Testing of HSE for large scale application
- Incorporation of ET and Rainfall

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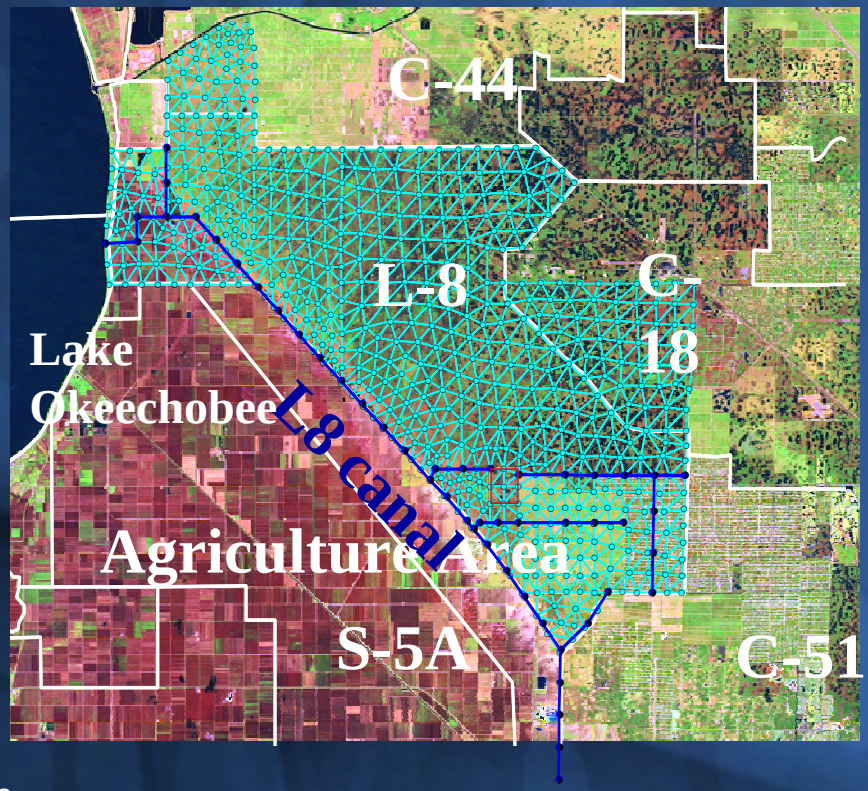
Early RSM Applications highlights & lessons

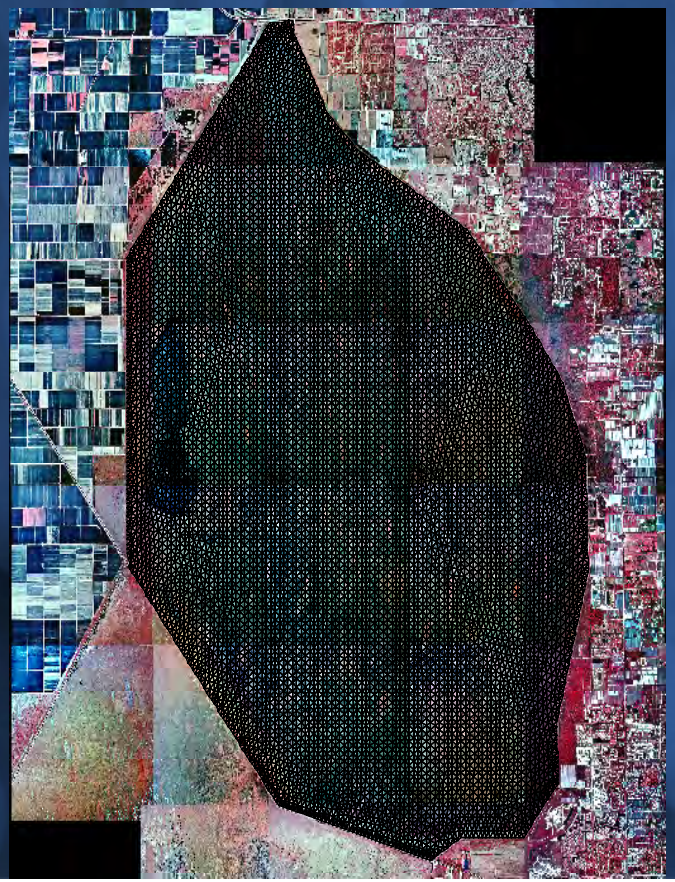
L-8 Drainage Basin



- Need for Hydrologic Process Modules
- Role of Levees and culverts in obtaining more realistic solution
- Helped develop detailed understanding of canal/aquifer interaction
- First truly integrated RSM application
- 1D / 2D lookup tables for structure operations

Early RSM Applications highlights & lessons

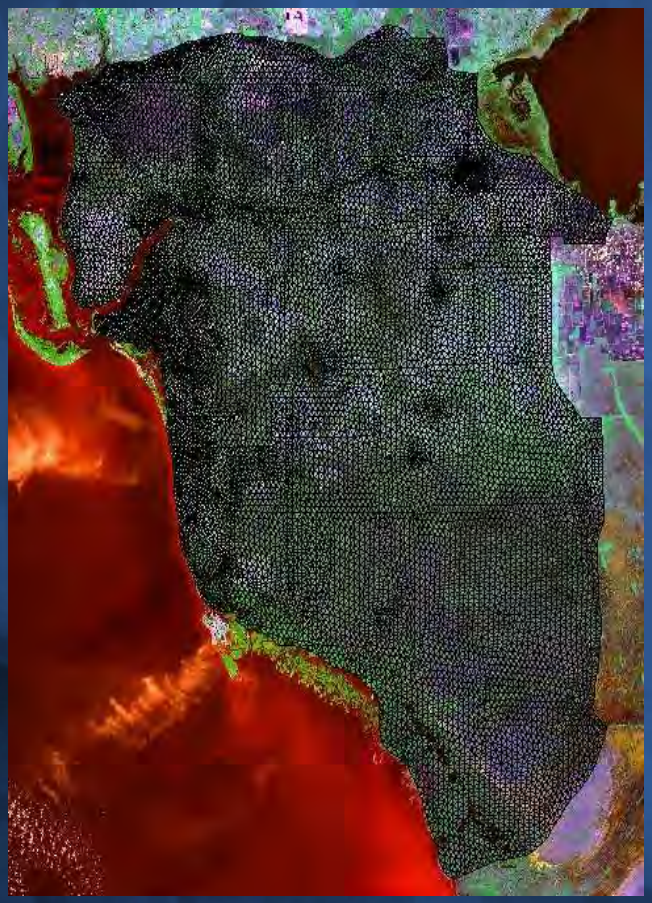
Loxahatchee National Wildlife Refuge (WCA-1)



- Canal /Overland flow interaction incorporated
- Demonstrated validity of solution for very flat slopes at basin level
- SV converter introduced for micro-topography
- Improved calibration techniques (auto-calibration)

Early RSM Applications highlights & lessons

Southwest Florida



- Different solution methods built in as option for steep slopes to handle stiffness problems
- Increased integration of GIS in developing input files
- Started using Python tools
- Assessment of operational complexity
- 3D capability introduced to handle multiple layered aquifer

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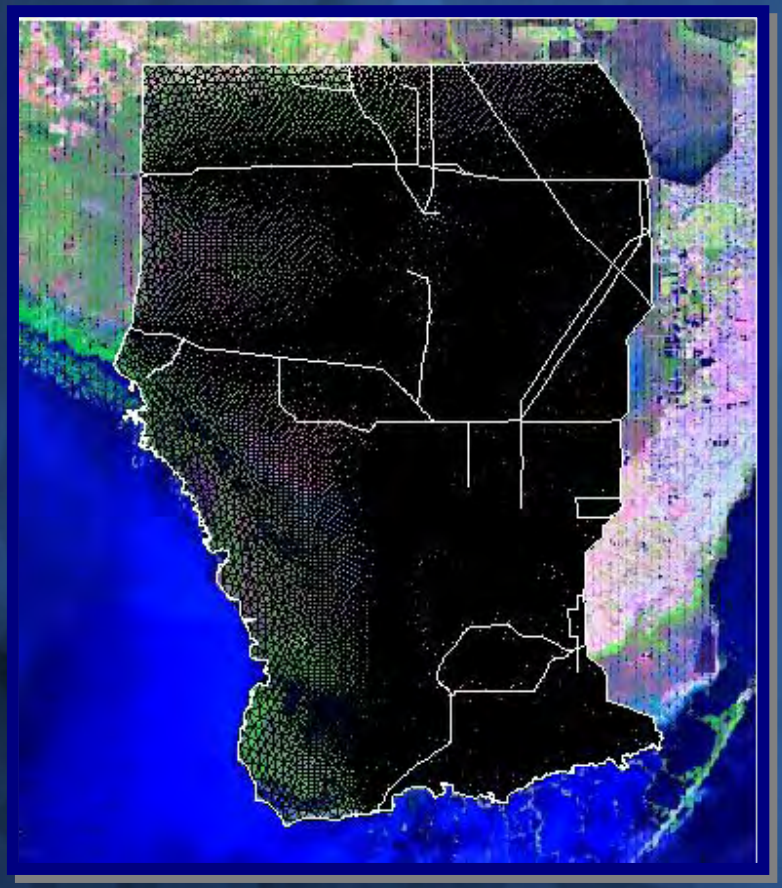
Early RSM Applications highlights & lessons

Southern Everglades



- Interior canal application
- Large number of culverts and structures
- Very fine mesh - tested practical limits of mesh resolution
- Used automatic calibration (SCE-UA)
- Very promising calibration / verification results

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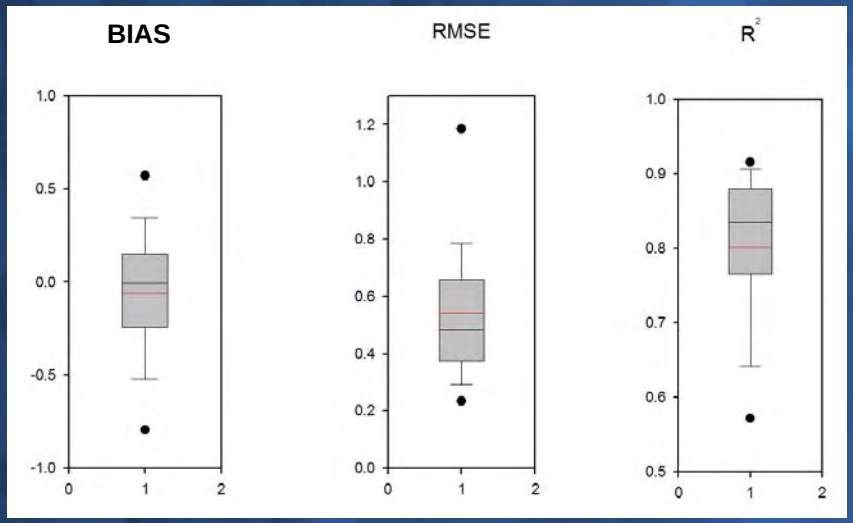
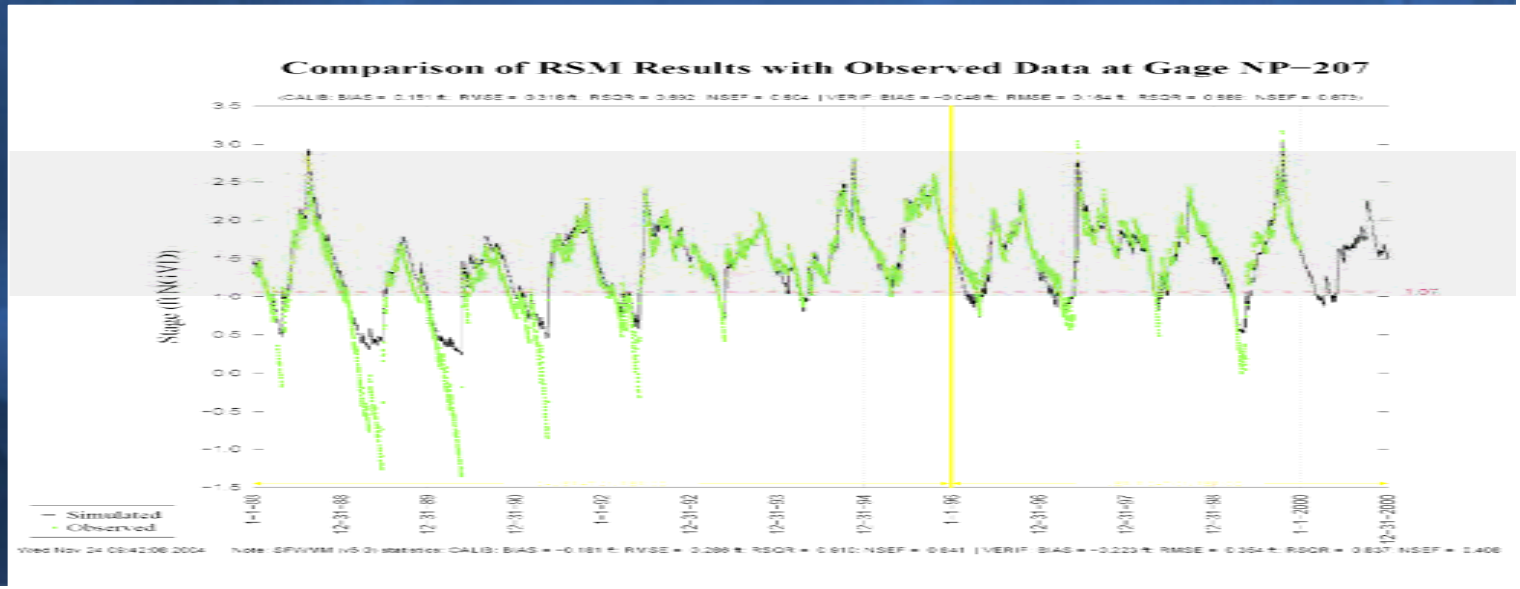
Early RSM Applications highlights & lessons



Southern Everglades

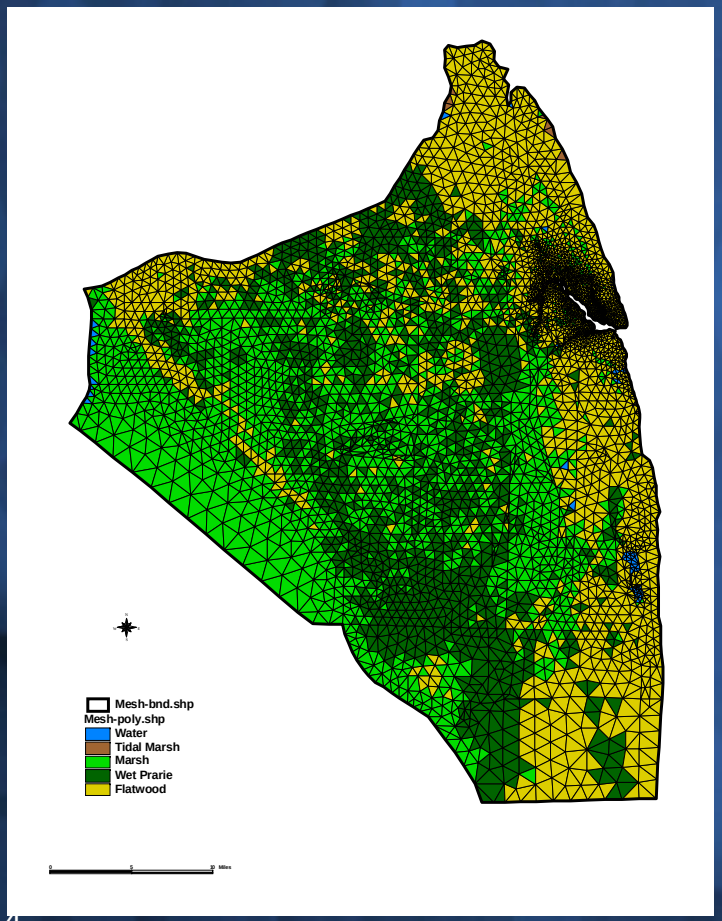
Sample Calibration for Marsh

79 marsh gages
8 years daily calibration



Early RSM Applications highlights & lessons

North Palm Beach County Pre-Drainage Conditions



- Long term simulations tested (1965-2000)
- SV converter realtionship based on LIDAR data at selected locations was implemented
- Tidal boundary condition
- Application to develop wetland / stream restoration targets

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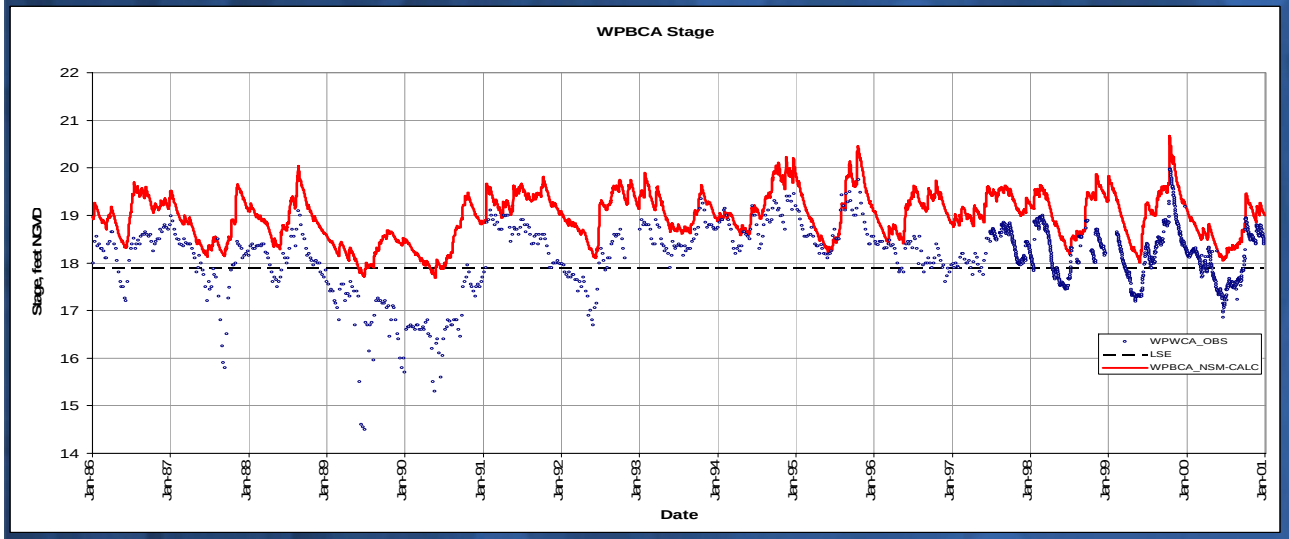
Early RSM Applications highlights & lessons

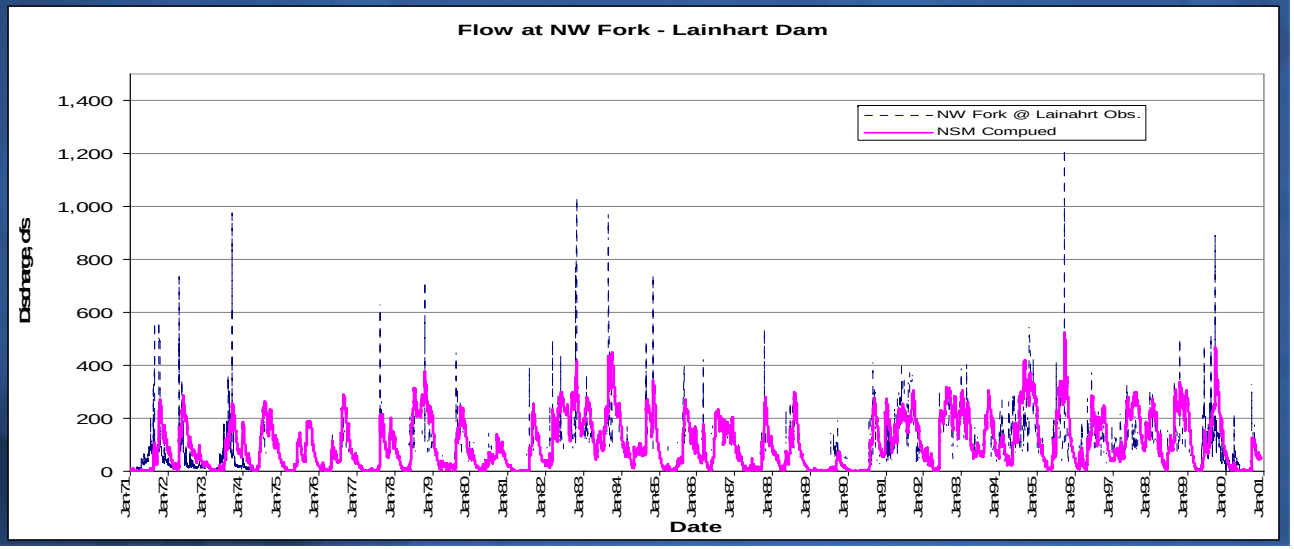
North Palm Beach County Pre-Drainage Conditions



Application

Pre-drainage vs recent observed stage

Pre-drainage vs recent observed flow



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MISSION STATEMENT

- **Develop a calibrated and verified RSM application [South Florida Regional Simulation Model (SFRSM)] by December 2005.**

- **This model will include necessary regional level operations functionality to be used for a screening level analysis of alternatives.**

SFRSM Implementation & Application

Expected Applications :

- Planning tool to address long term continuous simulations
- Daily time step simulations of multi-day events
- Relative comparisons between modeled alternatives

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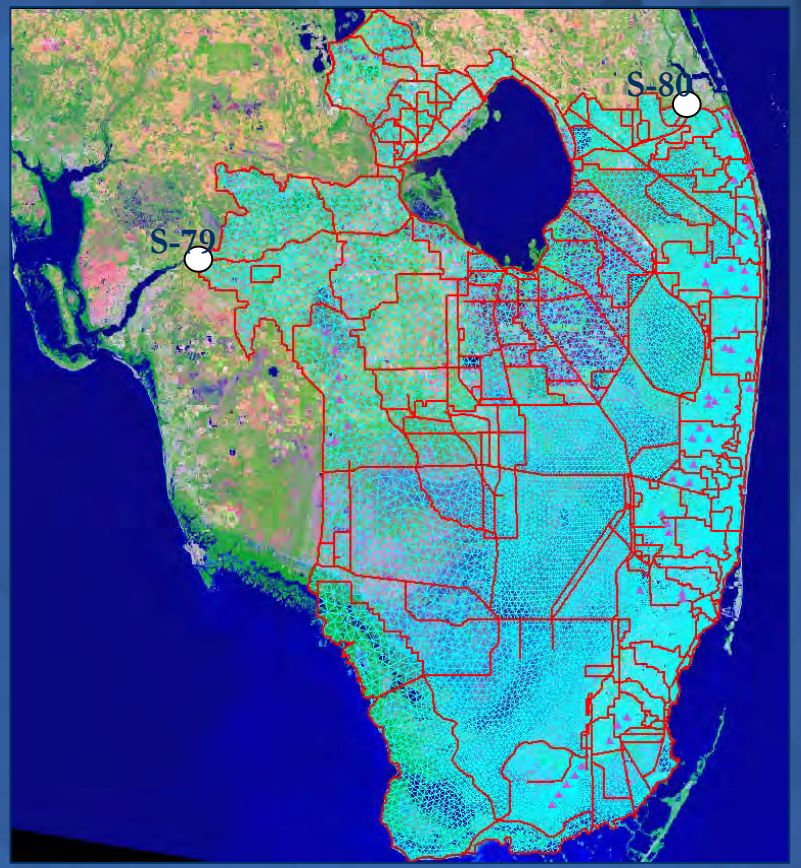
SFRSM Implementation & Application

Implementation Assumptions

- Domain Includes Lake Okeechobee Service Area, Caloosahatchee Basin to S-79 and St. Lucie Basin to S-80.
- Lake Okeechobee and Service Area outside of mesh will be simulated using a lumped approach
- Use a one-day time step (less if stability issues arise)
- Region-scale model and not specifically handle project scale design features
- Will not simulate flood events requiring small time steps
- Will simulate all primary and some secondary canals
- Will be a single layer model and handle surficial aquifer only
- Will simulate effects of major flow-barriers



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Specific Peer review Comments

- Domain of SFRSM vs SFWMM
- Lake Okeechobee interaction
- Mesh discretization
- ET and rainfall over canals

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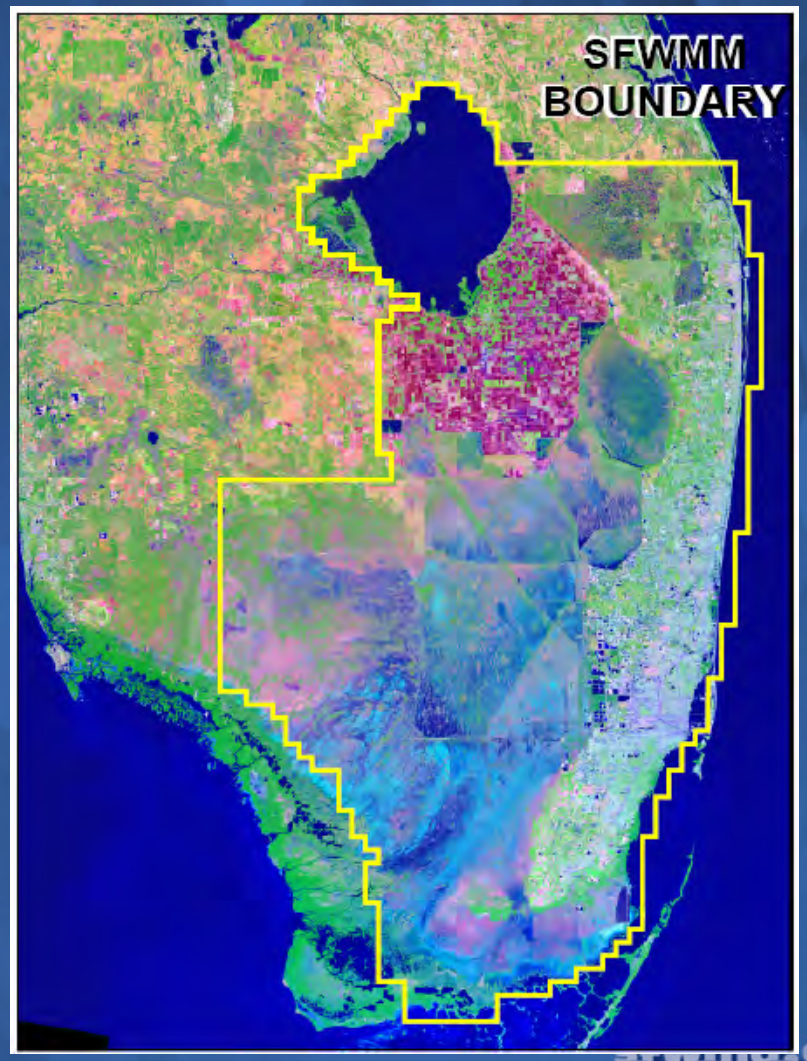
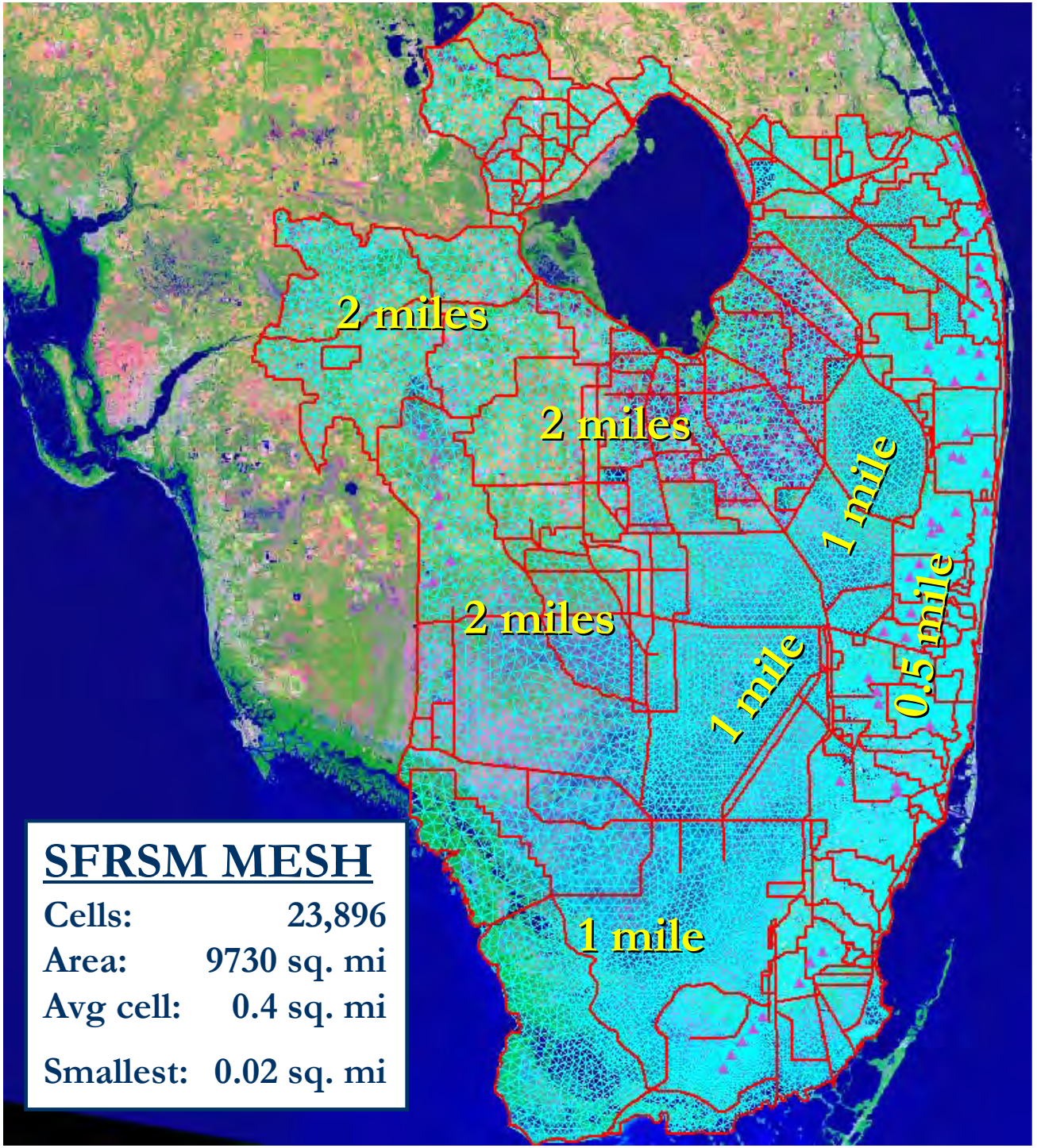
SFRSM vs SFWMM domain





SFRSM MESH

Cells:	23,896
Area:	9730 sq. mi
Avg cell:	0.4 sq. mi
Smallest:	0.02 sq. mi

SFRSM Mesh

MESH RESOLUTION

- 2 miles in Agriculture
- 1 Mile in Natural
- 0.5 mile in LEC
- Local Refinement as Needed

MESH TESTING

- Elimination of distorted cells
- Error Analysis
  - Minimum cell size to reduce errors
  - Max cell size to maintain diagonal dominance

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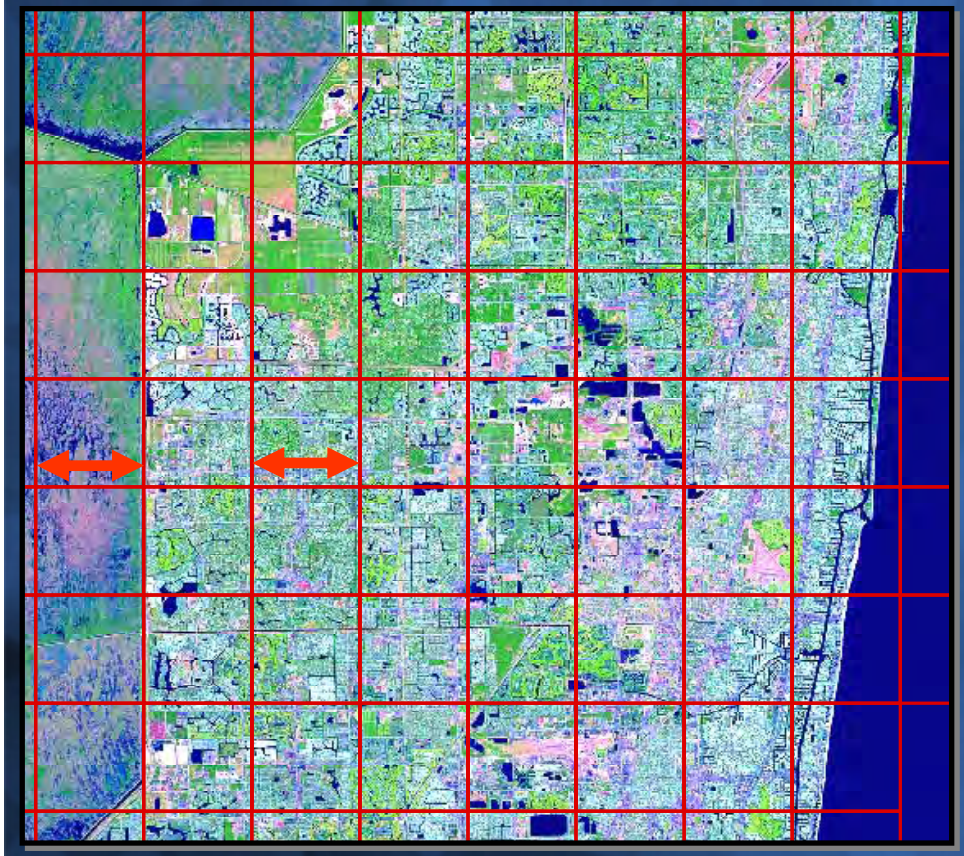
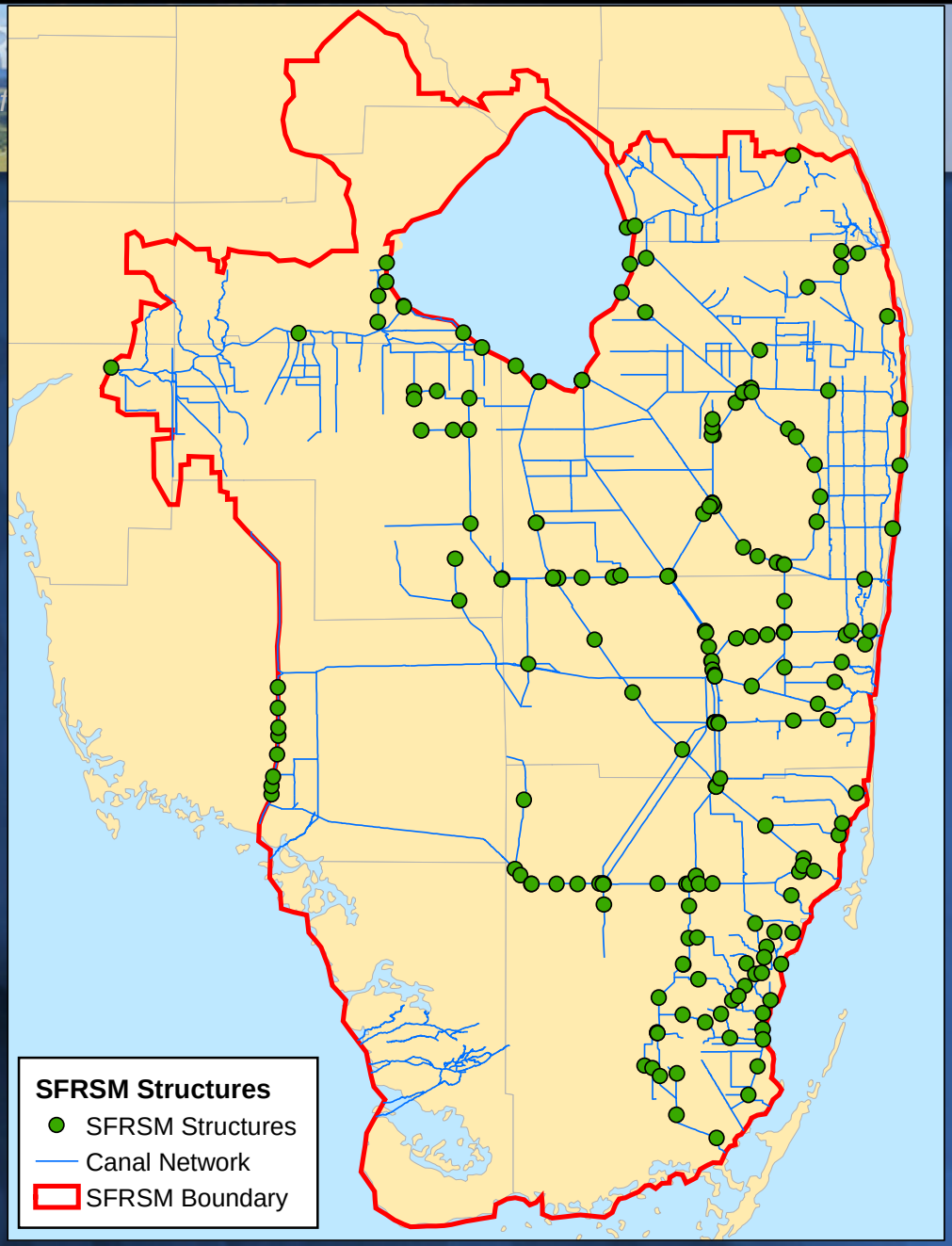
SFWMM vs SFRSM Mesh

SFWMM (2 X 2)



SFRSM

SFRSM canals & structures



- All SFWMD primary canals and some secondary are directly represented in the model
- The effect of other secondary and tertiary canals are modeled indirectly using Water Control District effective canals or HPMs
- Approximately 250 structures used currently by SFWMD operations will ultimately be represented in the model

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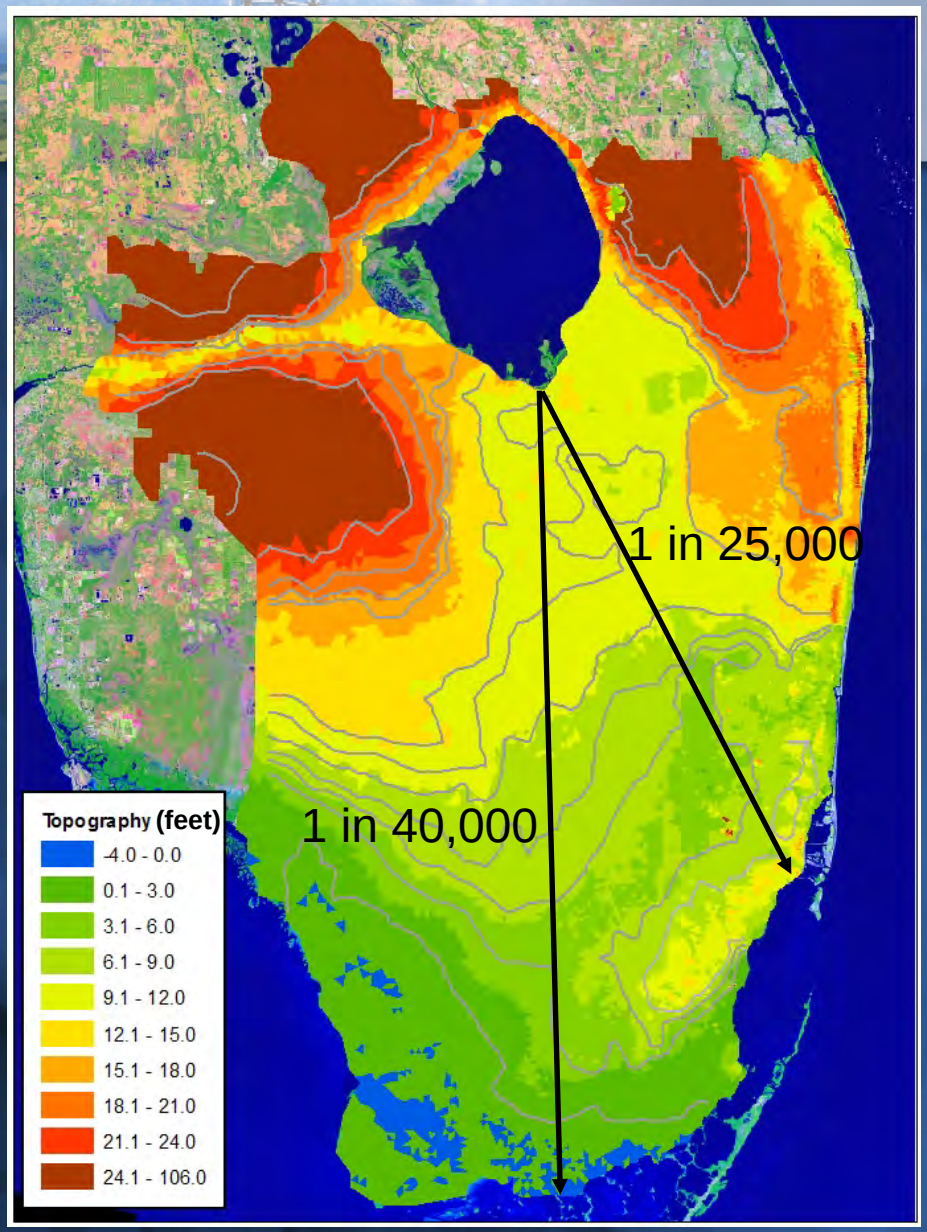
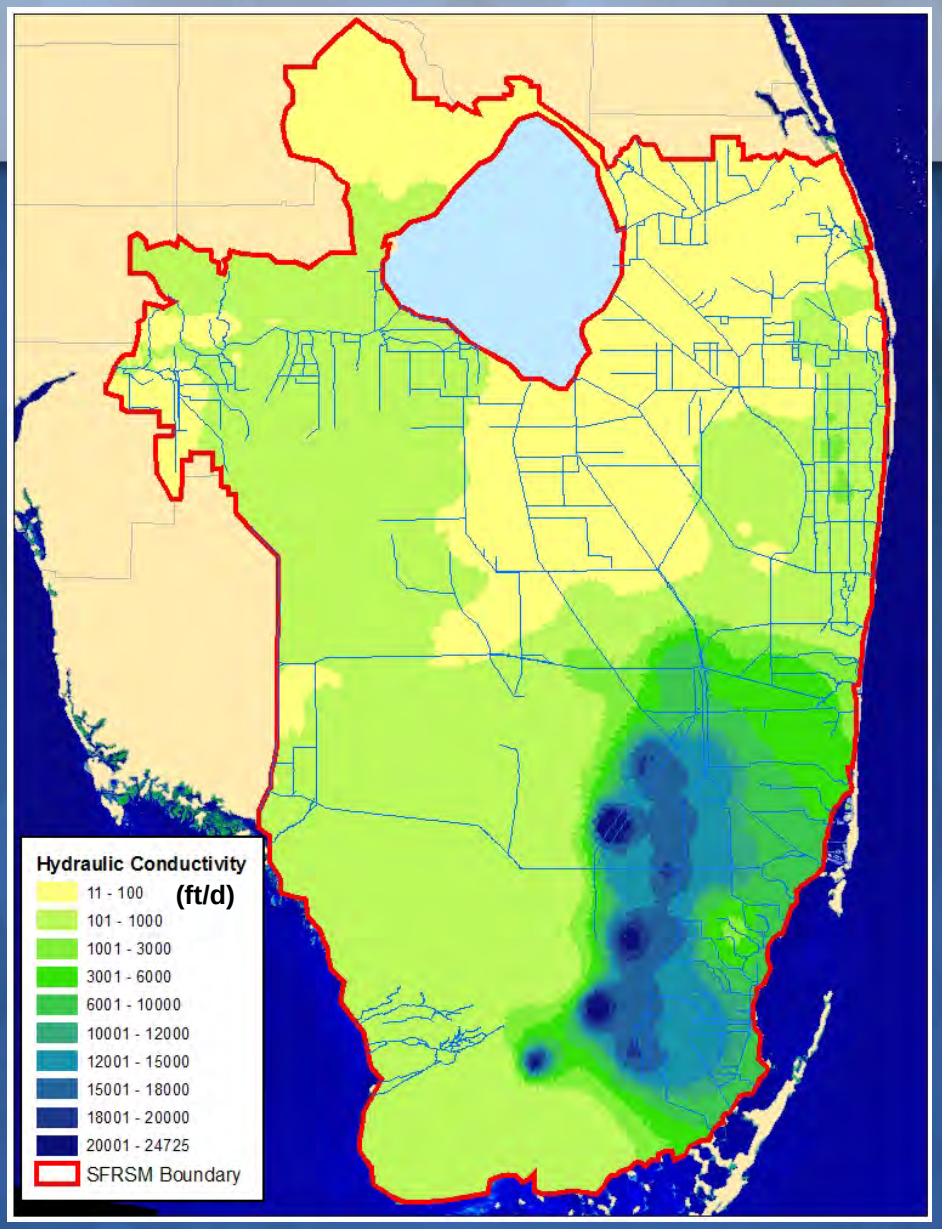
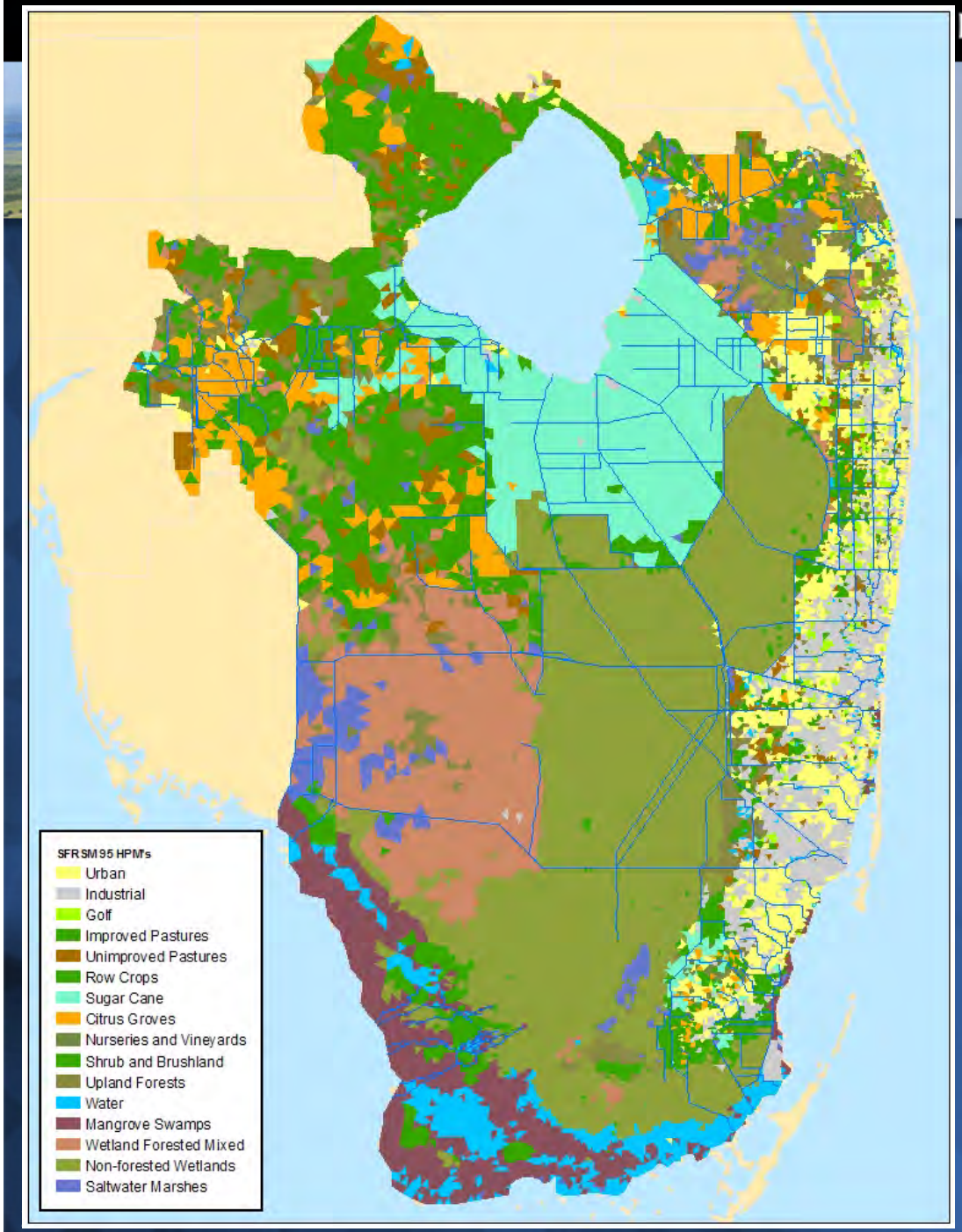


Topography



Hydraulic Conductivity

SFRSM Land Cover



1995 Land Cover

- 16 categories

Implemented into

3 Main HPM Types

- Natural
- Agriculture
- Urban

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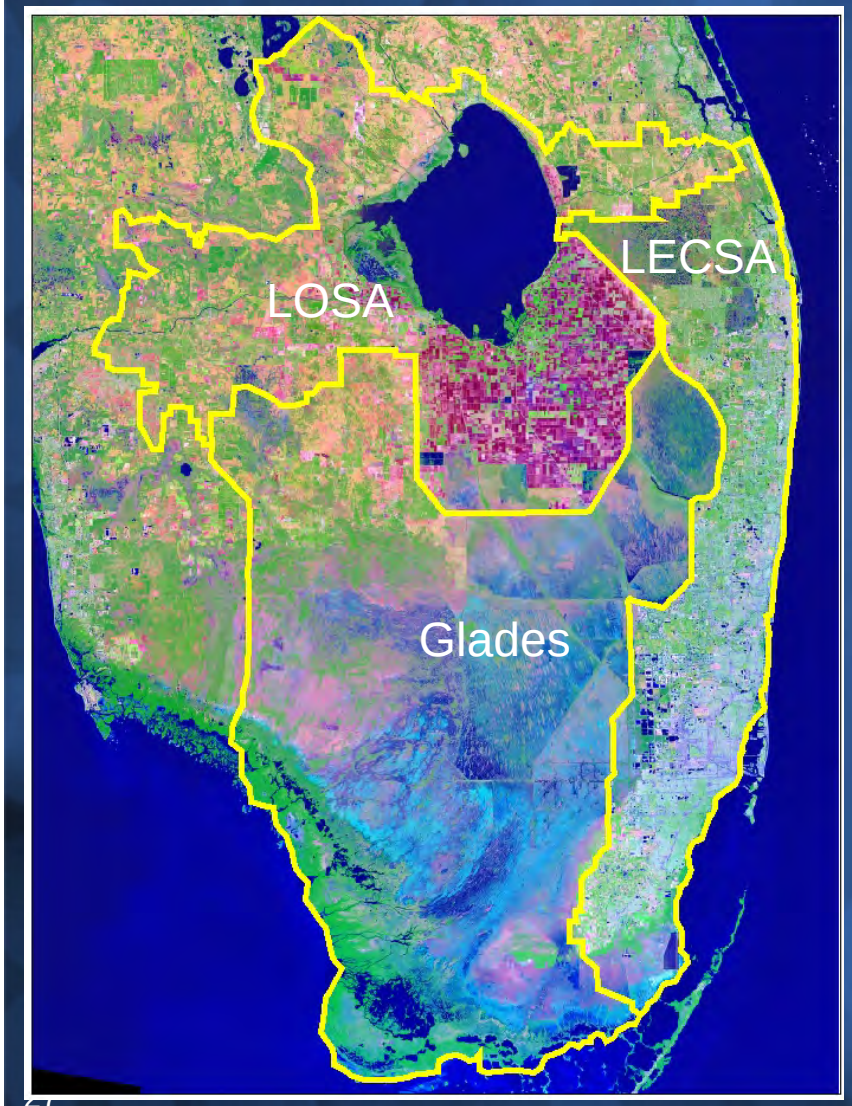

Calibration Approach

- Initial data collection, mesh generation, testing (Alpha versions)
- Phase 1. Basin sub-team breakout: further checking of data (Beta version)
- Phase 2. Model testing using specified canal stages throughout (SFRSM v1.1.1)
- Phase 3 & 4. Initial and refined calibration with different approaches by basin
- Phase 5. Integration, final calibration and verification

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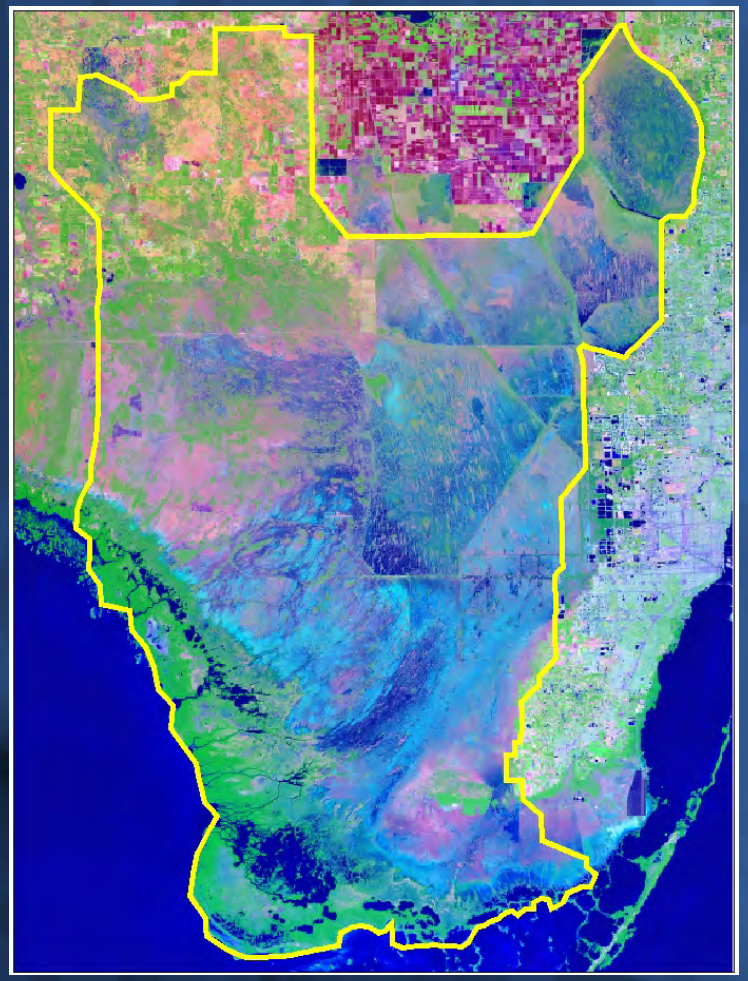

Glades basin approach

- Initially use single land cover and single HPM type <layer1nsm>
- Impose flows at all structures using historical data, simulate as necessary
- Increase complexity of land cover and HPMs as necessary
- Adjust ET coefficients by land use as main adjustment coefficient

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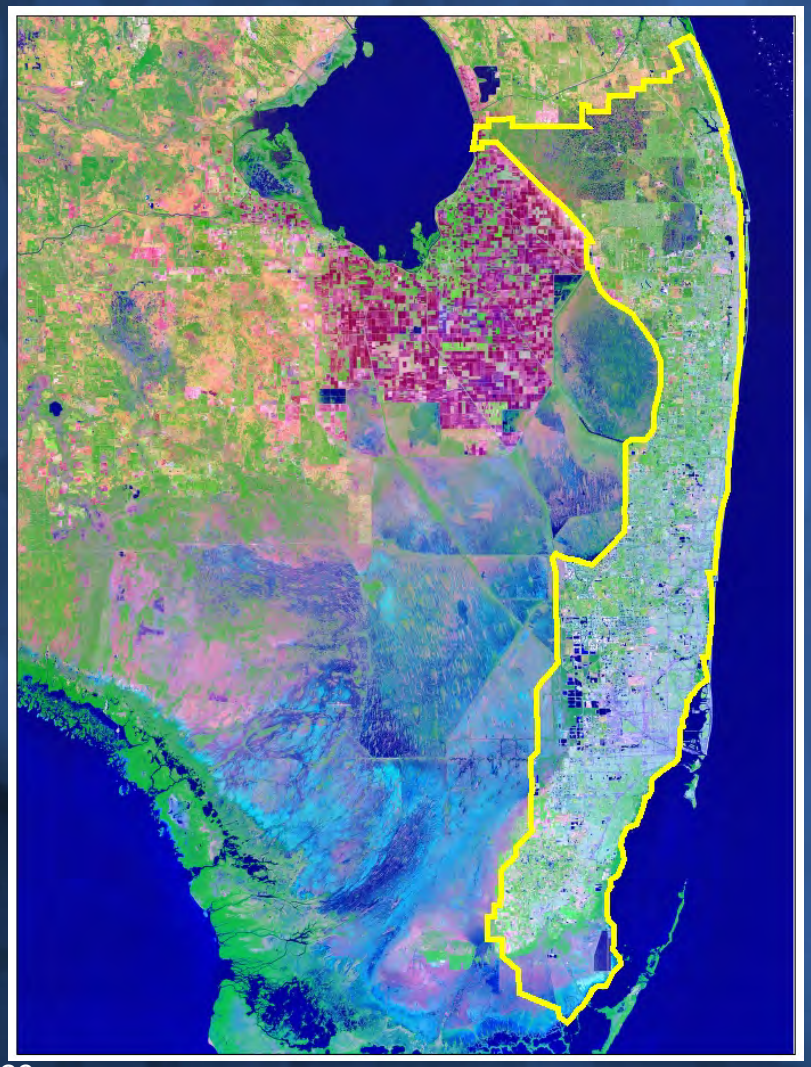

LECSA basin approach

- Divide area into sub-basins and create test beds for each
- Build canal network incrementally. Basic approach: impose observed flow at u/s end & observed stage at d/s end
- Main adjustment parameters:
  - canal to cell seepage
  - levee seepage
- Incorporate operations for selected structures

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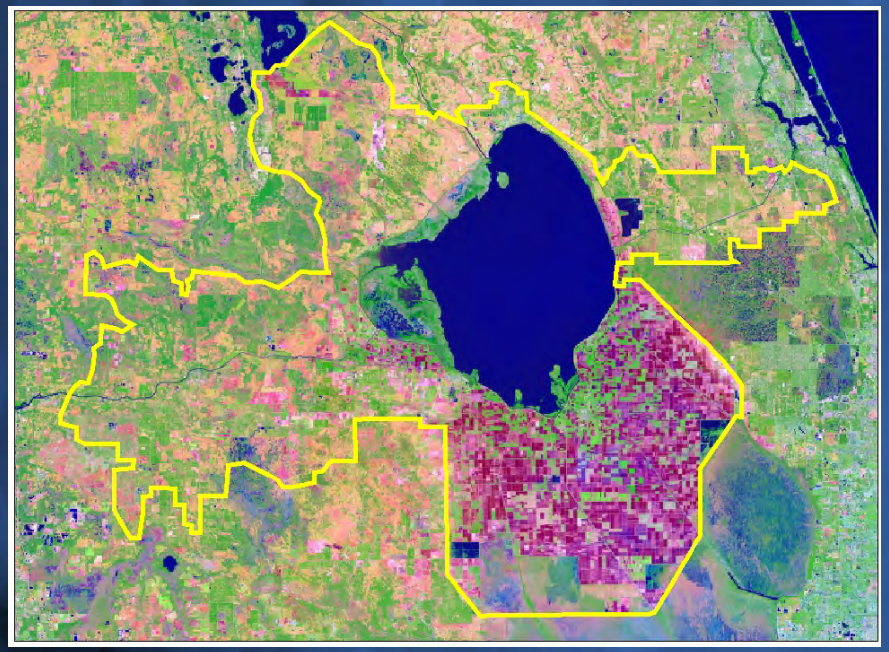
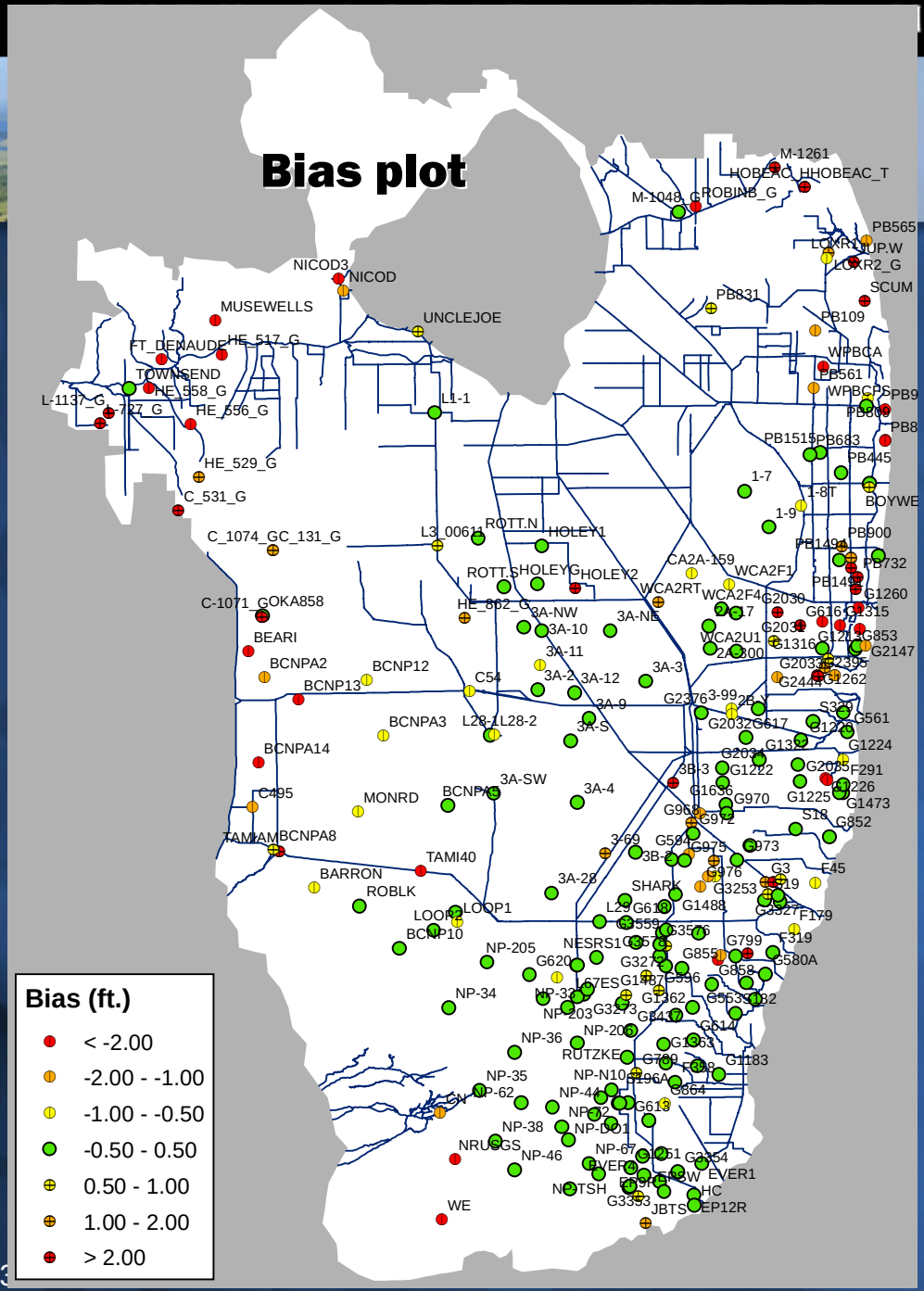
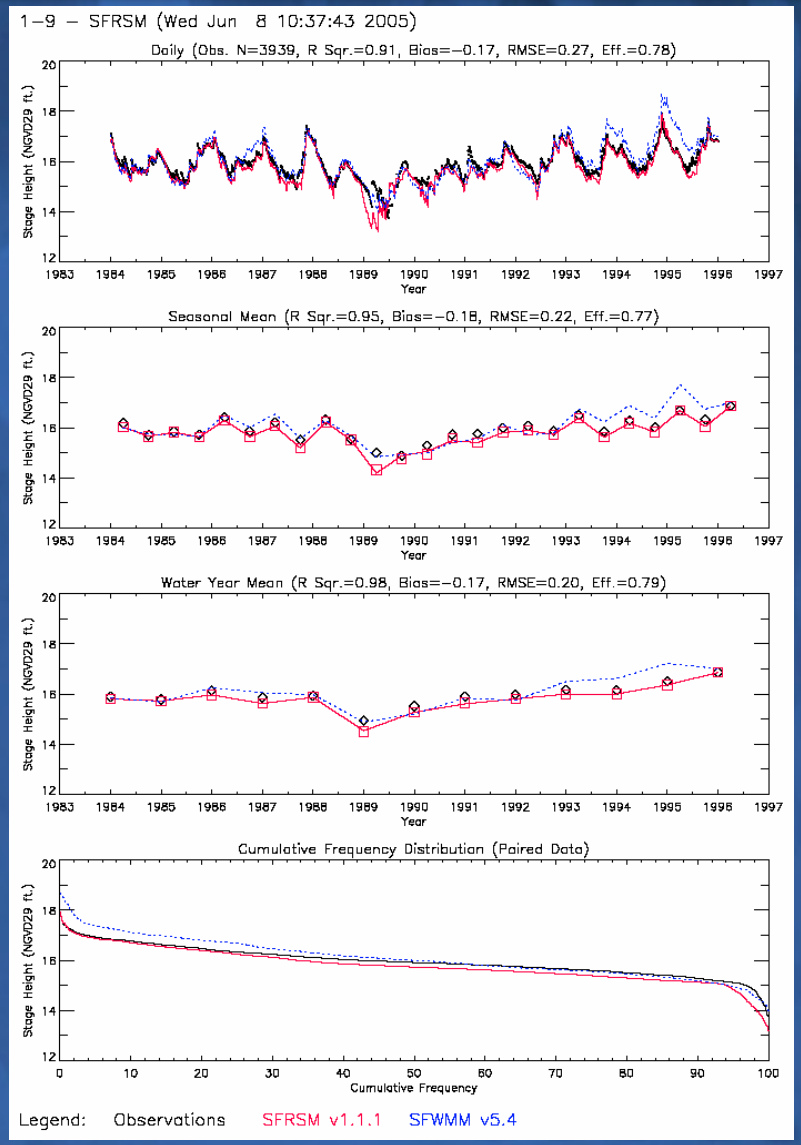


LOSA basin approach

- Subdivide into Caloosahatchee, St. Lucie and EAA
- Initially single basin for each sub-area comparing runoff and demand
- Include minor basin subdivisions
- Incorporate more complex HPMs and hubs
- Impose flow at downstream end of canals and route water to major canals

SFRSM Initial Calibration sample results





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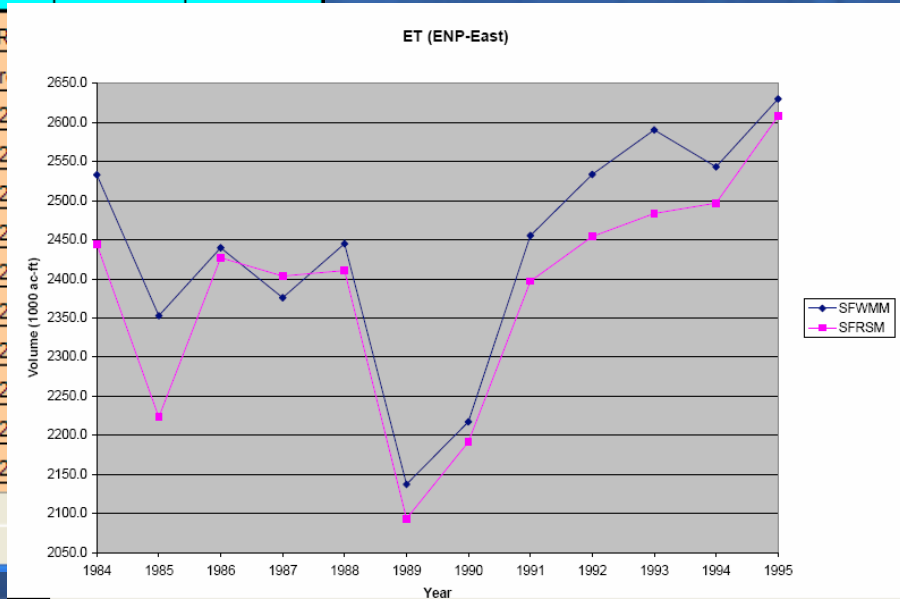
SFRSM Initial Calibration sample results

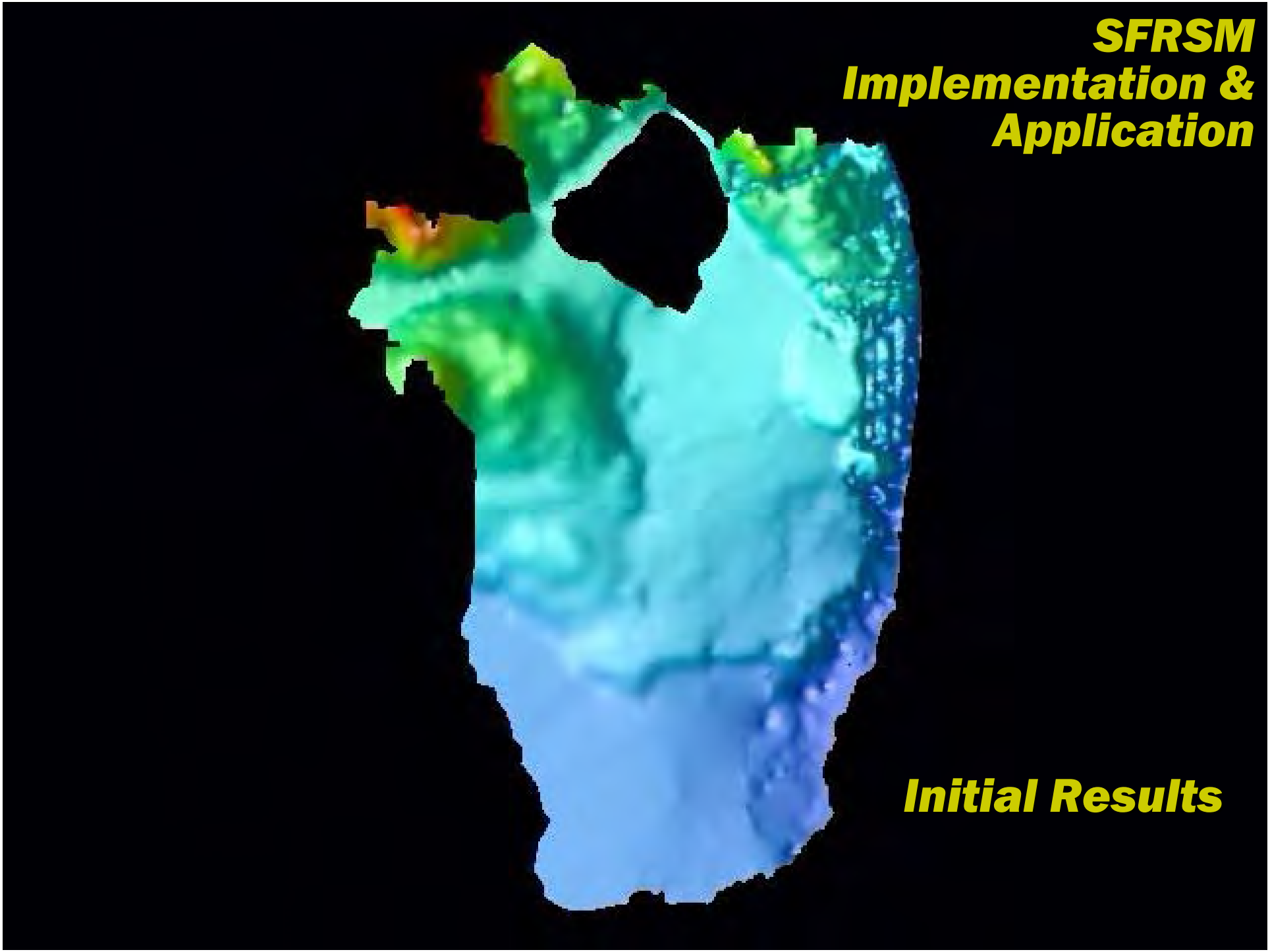
	Eastern Palm Beach								
	Rainfall (RSM_eq)	Rainfall (WMM)	Rainfall	Et (RSM_eq)	Et (WMM)	Et	PWS (RSM)	PWS (WMM)	PWS
	Th-acre-ft	Th-acre-ft	% differe	Th-acre-ft	Th-acre-ft	% difference	Th-acre-ft	Th-acre-ft	% difference
1984	2745.9	2766.9	-0.76	1701.1	1417.1	20.04	149.3	149.4	-0.04
1985	2426.9	2424.9	0.08	1648.4	1406.1	17.23	158.5	158.5	0.00
1986	2934.9	2954.2	-0.65	1742.3	1449.7	20.18	163.2	163.2	0.01
1987	2452.6	2464.7	-0.49	1626.3	1373.7	18.39	182.0	182.0	-0.01
1988	2407.7	2440.7	-1.35	1666.1	1405.5	18.54	186.7	186.7	-0.01
1989	2039.8	2011.3	1.42	1575.5	1379.3	14.23	204.7	204.8	-0.05
1990	2411.3	2436.8	-1.05	1646.7	1417.1	16.20	178.0	178.0	0.00
1991	3294.2	3323.2	-0.87	1824.1	1503.8	21.30	188.0	188.0	-0.02
1992	2964.6	2926.6	1.30	1715.3	1466.2	16.99	194.9	195.0	-0.04
1993	2983.4	2925.6	1.98	1757.2	1481.6	18.60	197.8	197.8	-0.02
1994	3889.2	3820.7	1.79	1823.1	1524.4	19.59	190.7	190.8	-0.03
1995	3248.6	3213.8	1.08	1773.3	1508.8	17.53	195.1	195.1	-0.02
Average	2816.6	2809.1	0.27	1708.3	1444.4	18.27	182.4	182.4	-0.02
	Eastern Broward County								
	Rainfall (RSM_eq)	Rainfall (WMM)	% Differe	Et (RSM_eq)	Et(WMM)	% Difference	PWS(R		
	Th-acre-ft	Th-acre-ft		Th-acre-ft	Th-acre-ft		Th-acr		
1984	1435.8	1462.7	-1.84	1044.8	703.8	48.44	2		
1985	1455.9	1487.9	-2.15	1025.8	717.4	42.99	2		
1986	1529.5	1541.5	-0.78	1080.3	723.2	49.38	2		
1987	1299.8	1329.8	-2.26	1013.9	701.8	44.47	2		
1988	1107.5	1118.2	-0.95	958.1	693.2	38.21	2		
1989	947.5	942.3	0.56	964.1	682.9	41.17	2		
1990	1323.6	1302.2	1.65	1045.3	695.1	50.39	2		
1991	1795.3	1755.6	2.26	1092.6	706.6	54.62	2		
1992	1565.1	1506.2	3.91	1033.7	702.0	47.26	2		
1993	1359.5	1349.2	0.77	1034.2	693.9	49.05	2		

Sheet1 / Sheet2 / Sheet3 / Sheet4 / Sheet5 /

Soft Calibration

Water Budgets

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Initial Results

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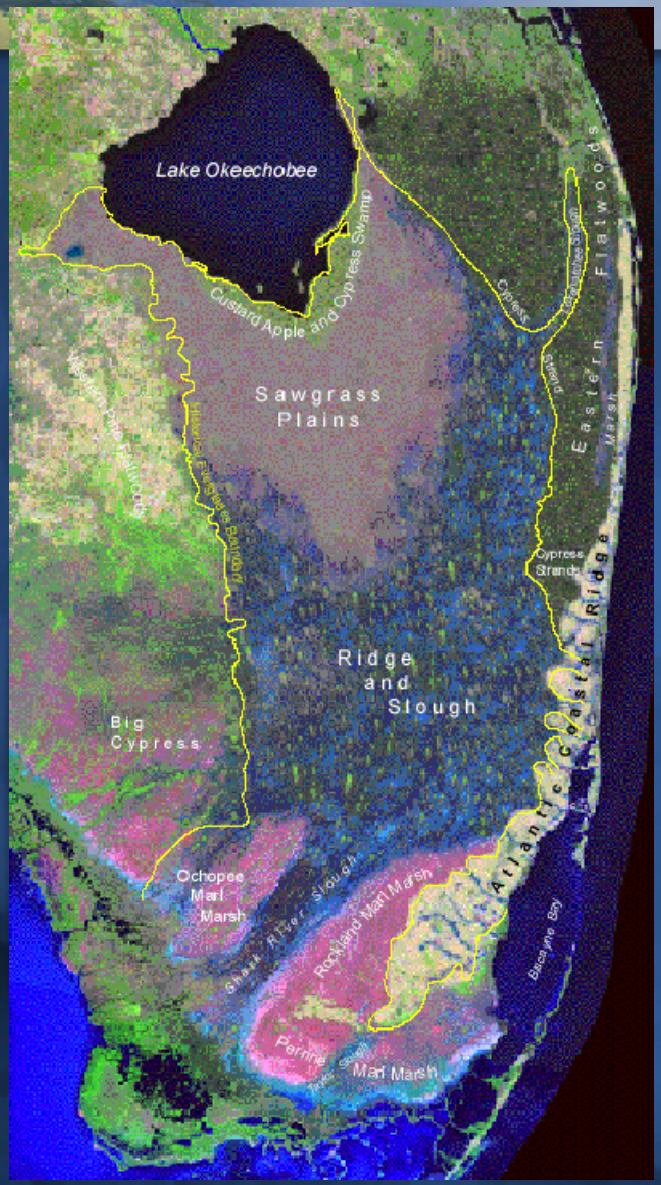
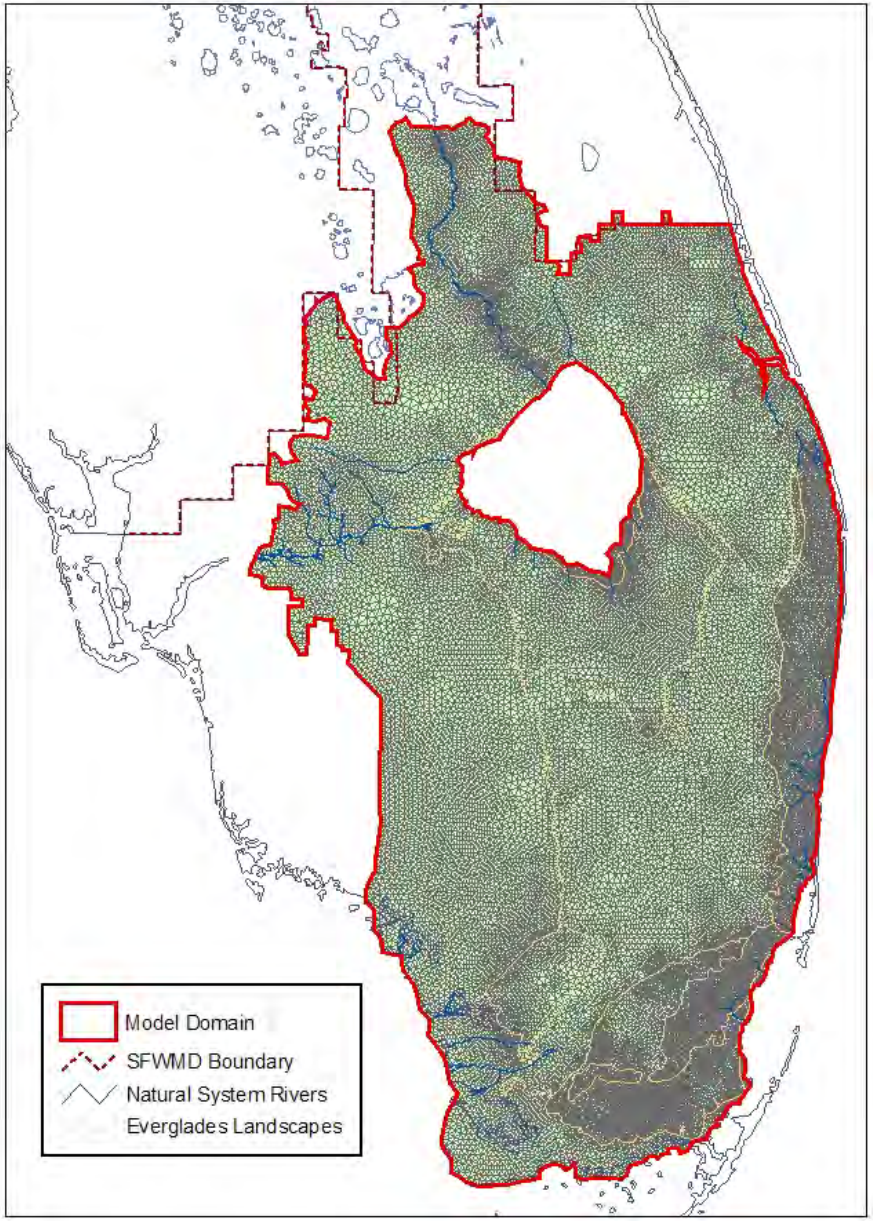
NSRSM Pre-Drainage Application



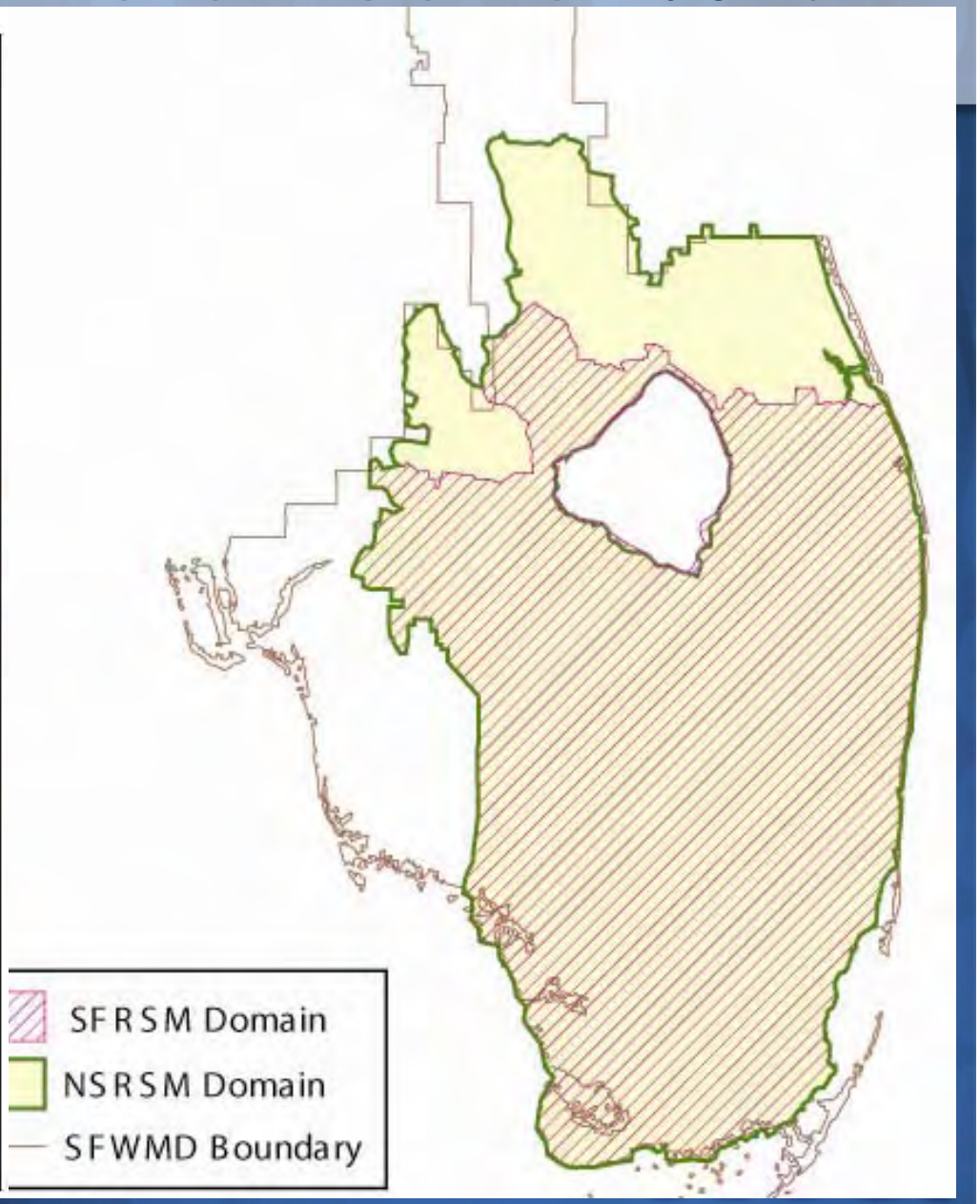
Best estimate of pre-drainage response to recent climatic input data

Often used to help determine or set restoration targets

NSRSM mesh



NSRSM vs SFRSM domain



NSRSM data

- Time Series POR 1895 – 2000

  (Currently run 1965-1995)

  - Rainfall (historic closest station)
  - Evapotranspiration: Temperature based on VEMAP (NOAA) and PRISM (OSU) data sets
  - Tides
- Historical Data
  - Topography
  - Landcover

Goal 8: Meeting Client Goals

Peer Review Goal 8 :

Evaluate whether the model is suitable for meeting client goals

- Client expectations
- Tools to meet client needs

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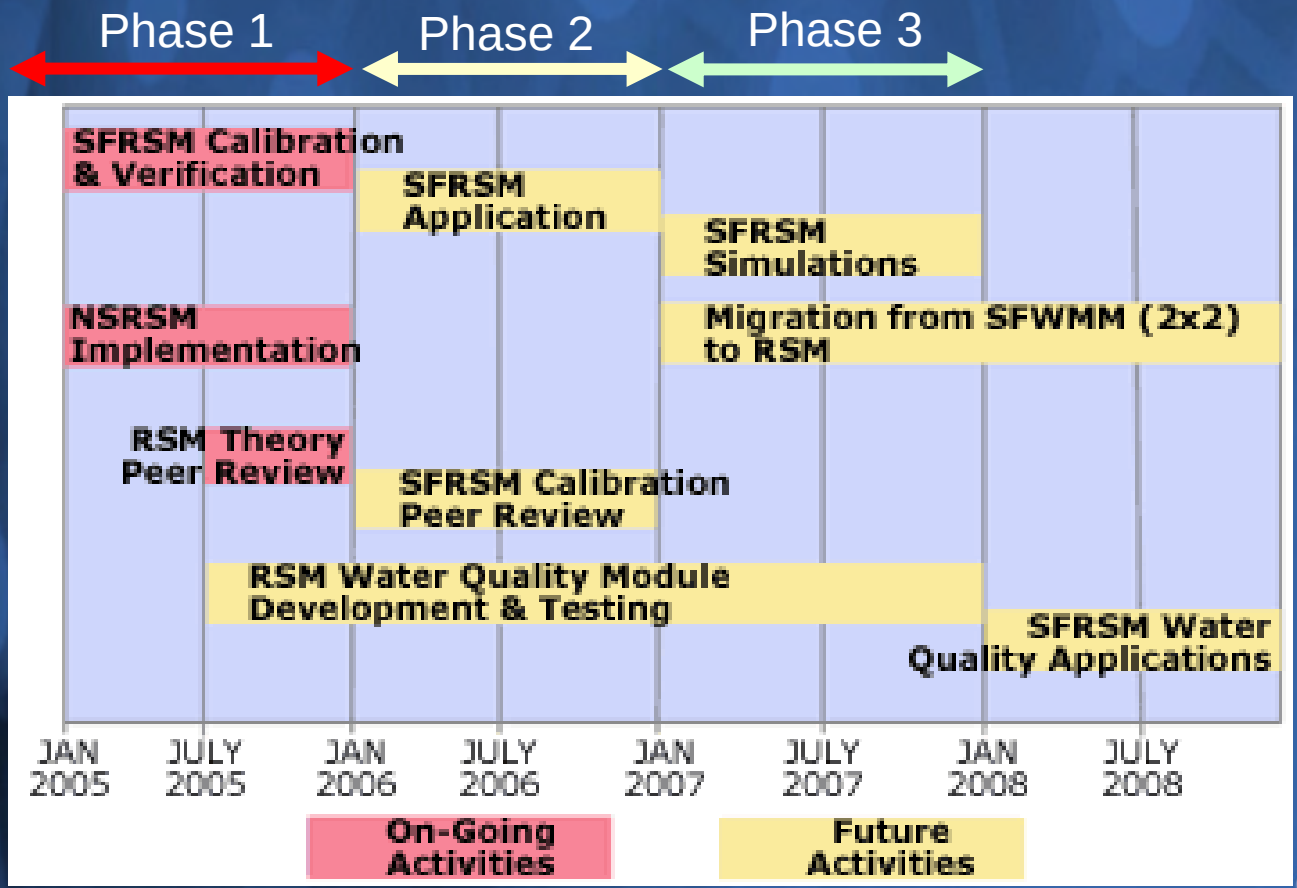
Goal 8: Meeting Client Goals

Client expectation management:

- Phased approach
- Available to evaluate alternatives in 2007



SFRSM Client Expectations

- Relative to SFWMM
- Model Code Conceptualization
- Client Coordination
- SFRSM Model Components
- SFRSM Application Use
- Regional Model Results Improvement

SFRSM Client Expectations

Relative to SFWMM

- Calibrate for water levels at least as well as the SFWMM (in terms of overall and distribution of Bias, R^2 and RMSE) [Phase 1]
- Improved structure flow calibration [Phase 2]
- Simulate water levels for remainder of LOSA and greater portion of Big Cypress National Preserve (BCNP) Basin [Phase 1]
- Flexible mesh that more closely approximates actual boundaries of the modeling domain [Phase 1]
- Greater mesh resolution in tree island, wetland, and ridge and slough areas [Phase 1]
- Improved hydraulic simulation of canals [Phase 1] & [Phase 2]
- Want to use to conduct basin-scale simulations [Phase 3]

SFRSM Client Expectations

Model Code Conceptualization

- Availability of graphical portrayal of various components of HSE and MSE and their interaction [Phase 1]
- How does SFRSM fit into the big picture of regional modeling at SFWMD [Phase 1]

SFRSM Client Expectations

Client Coordination

- Migration strategy from 2x2 and roll out plan be available to other departments [Phase 3]
- Staff from other departments be invited in some technical discussions to ensure concerns are addressed [Phase 1] & [Phase 2] & [Phase 3]
- Representation in sub teams meetings to get regular update of model implementation progress [Phase 1] & [Phase 2]
- Expand user pool and training should include staff from other departments [Phase 3]
- Client base should include all interested parties [Phase 3]
- Both SFRSM and NSRSM should be peer reviewed [Phase 1] & [Phase 2]
- Consistent, “similar look and feel” of GUI portions of Performance Measures [Phase 2]

SFRSM Client Expectations

SFRSM Model Components

- Able to integrate multiple disciplines: hydrology + water quality, ecology, hydraulics, etc. [Phase 2] & [Phase 3]
- Be able to handle small gate openings associated with water supply scenarios. [Phase 2] & [Phase 3]
- Be able to perform more sophisticated water shortage area analysis [Phase 2] & [Phase 3]
- Ability to be used in Position Analysis mode and Operational Planning [Phase 3] and beyond
- Include rainfall (-driven) operations in the Everglades [Phase 3] and beyond

SFRSM Client Expectations

SFRSM Application Use

- Ability to readily perform cell-by-cell comparison between SFRSM and NSRSM [Phase 2]
- Water budget at secondary canal level [Phase 2]
- Sensitivity runs be made towards project base runs , e.g., CERP [Phase 3]
- Ability to translate model output to performance measures [Phase 2]
- Increased comfort in using regional modeling to address CUP/CERP issues [Phase 2] to [Phase 3]
- Be able to conduct water reservation studies (beyond [Phase 3])
- Be able to do synthetic weather generation within the model [not planned]
- Be able to address some saltwater intrusion issues [needs better definition]

SFRSM Client Expectations

Regional Model Results Improvement

- Conduct sensitivity and uncertainty analysis [Phase 1] & [Phase 2] & [Phase 3]
- Comparison against other regional models, e.g., MikeShe [not planned]
- Reasonable turnaround times for modeling and analysis [Phase 1] & [Phase 2] & [Phase 3]

Initial SFRSM Implementation

Sample Run time: 1983 to 1995 simulation

- "Alpha" SFRSM model
  - 13 year simulation
  - 23,916 mesh cells
  - RAD canal system (~420 segments)
  - 3 Different HPM cell types, 16 sets of attributes
- Run performed on Dell 2650 with 2.8Ghz Zeon P4 processor and 4GB RAM
  - Run time = 1hr and 18min
  - Output for stages and flow vector = 1.3 GB

RSM Tools

RSM Tools

- Pre-Processing Tools

- Post-Processing Tools

RSM Graphical User Interface Tools (GUI)

Pre-processing Tools

A Standard Set of Pre-Processing Tools Provide:

- Intuitive Interface to Replace Manual Data Processes
- Streamlined Standard Data Processing Methods
- Simplified Assembly of XML input Files
- Flexible Framework to Evolve with Model Development
- Consistent & Documented Scenario Building

- ✓ Built on a Documented GIS Database
- ✓ Offers a Visual Interface to Data
- ✓ Produces Compliant XML Data Sets

GIS Geodatabase

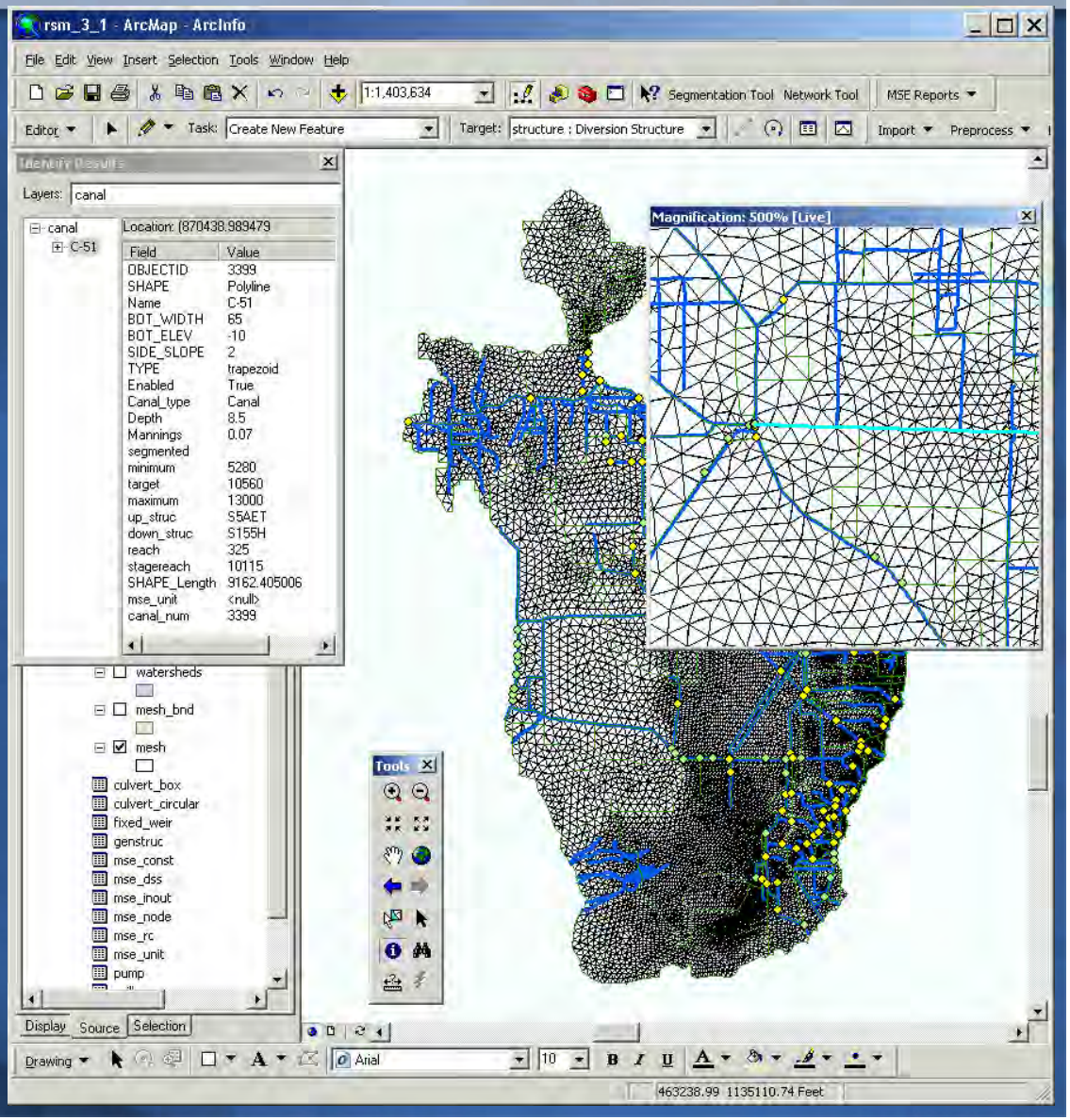
ArcGIS9 Geodatabase

Geometric network includes GIS feature classes, attributes pertaining to

- existing canals
- watermovers
- physical structure properties
- SFRSM mesh
- relational database tables
- relationship classes.

Each RSM scenario is assembled from a versioned geodatabase

XML input files for the RSM are generated directly from the database using pre-processing tools.



GIS Toolbar

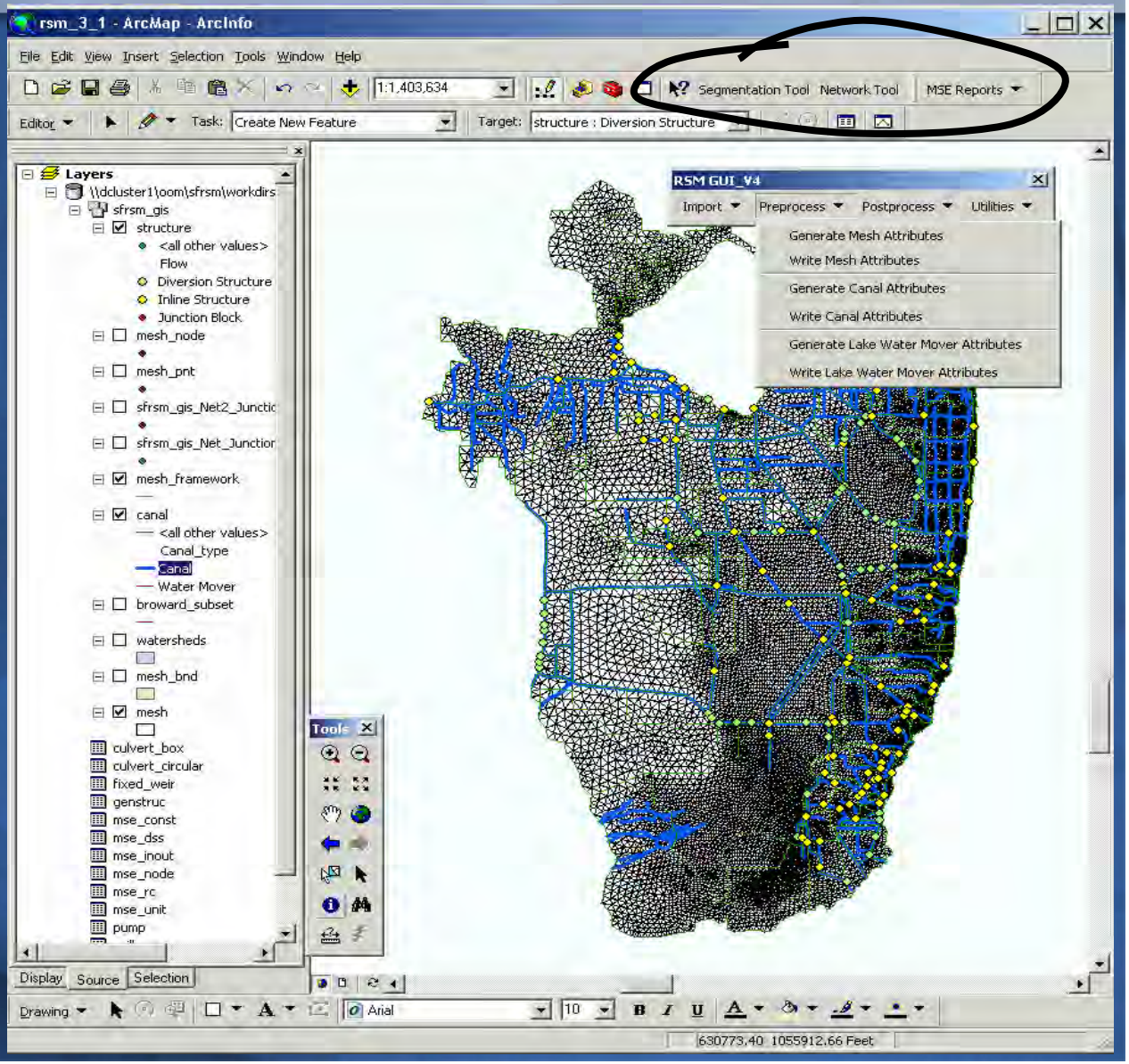
ArcGIS9 Toolbar

- GIS layers are combined with the geodatabase
- features are modified to create an SFRSM scenario

- Tools preprocess the SFRSM GIS and produce XML input files

Current Capabilities Include:

- Import Mesh Tools
- Intersect Mesh Tools
- Define Boundary Conditions
- Assign Watermover Attributes
- Assign Canal Attributes
- Assemble MSE Units
- Headstage Report
- Segment Canals
- Generate XML files

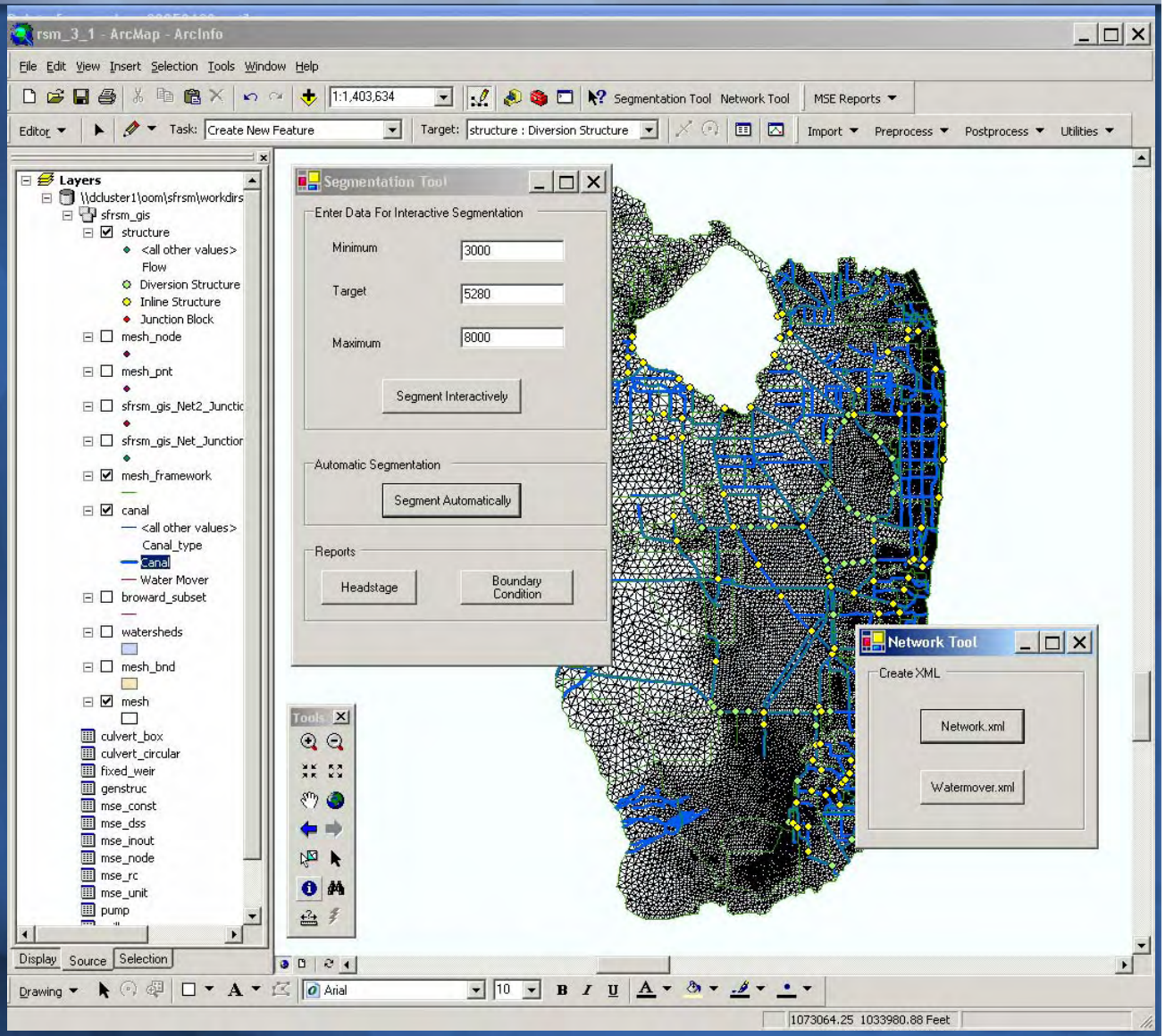


GIS Toolbar

ArcGIS9 Toolbar

Example:

- Segmentation Tool
- XML Output Buttons



RSM Graphical User Interface Tools (GUI)

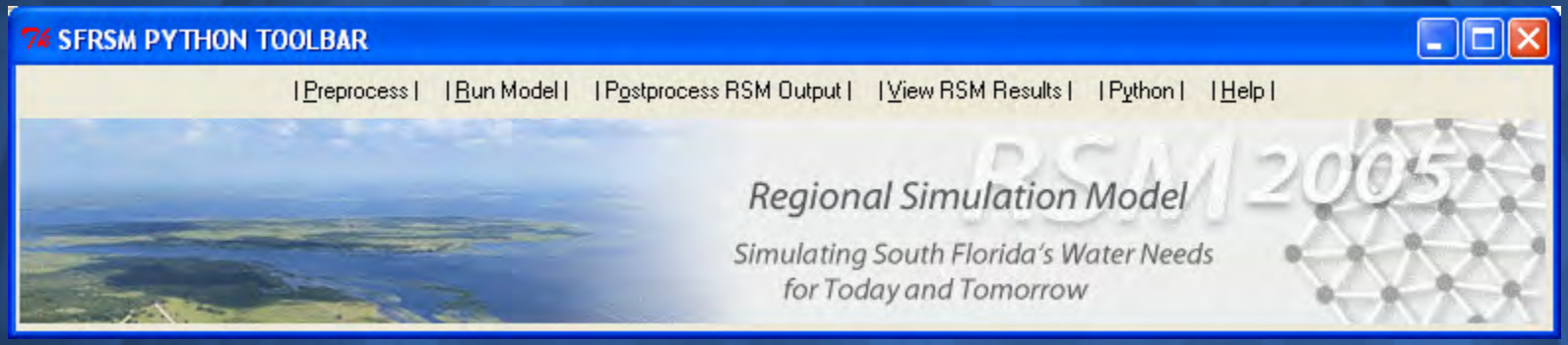
Post-processing Tools

A Standard set of post-processing tools provides

- An integrated toolbar
- Intuitive interface to run the model
- Standard data analysis methods
- Streamlined analysis workflow
- Flexible framework to evolve with model development
- consistent & documented model results comparisons
- Centralized set of help features

✓ Built on an opensource (python) platform
✓ Offers a visual interface to view model results
✓ Produces A documented model run & analysis

RSM Python Toolbar



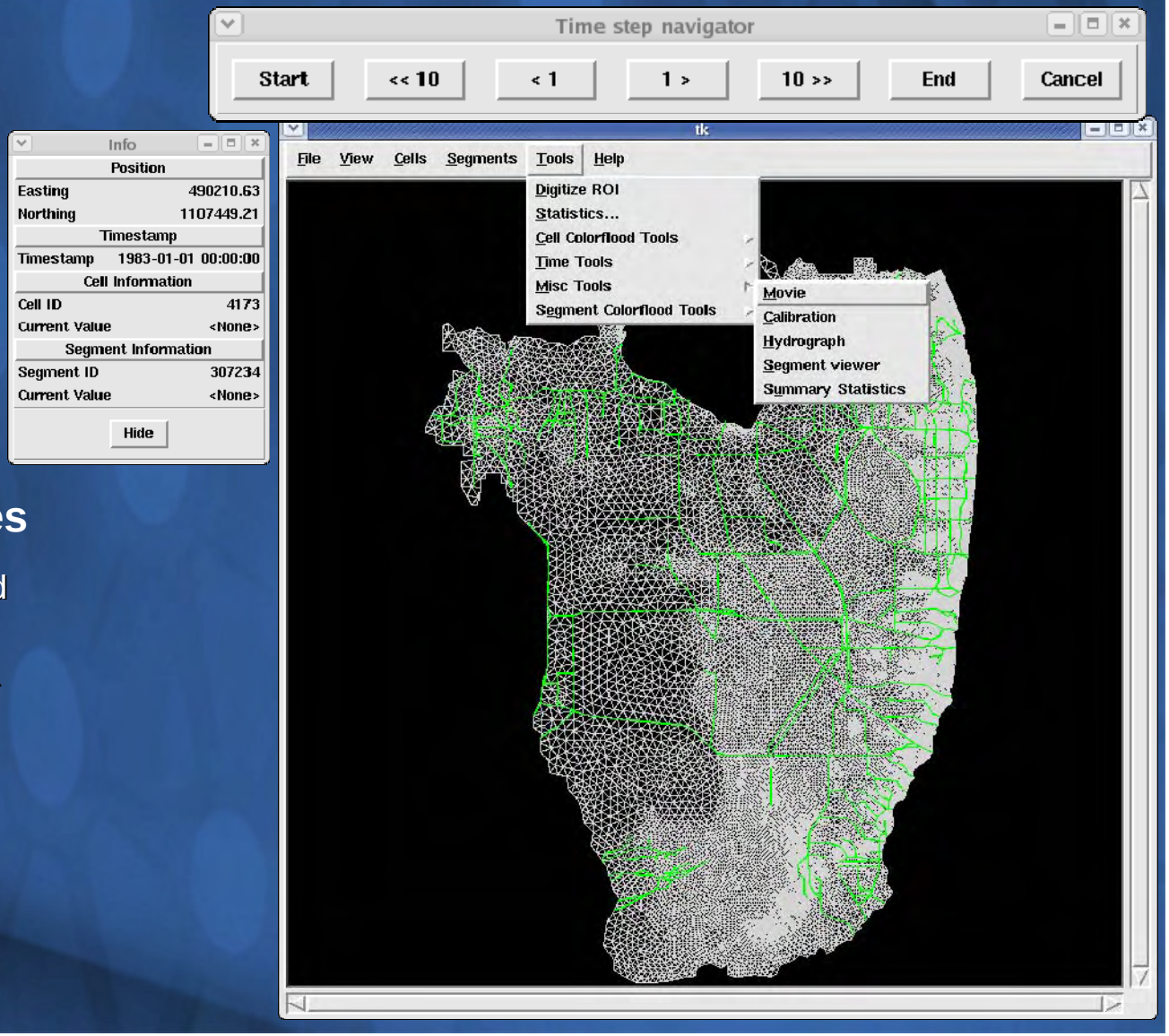
RSM Python Toolbar

Integrated toolbar - organizes non-geoprocessing (non-GIS) tools

- Features include
  - preprocess manipulation of XML files
  - run interface
  - post-processing graphic generation
  - result viewing
  - comprehensive help menu
- Toolbar is opensource platform independent design

RSM 2005
Office of Modeling

RSM Results Viewer



Results Viewer Features

- Output can be displayed and analyzed including
  - Timestep animation viewer
  - side-by-side hydrographs
  - statistical charts
  - timestep value displays

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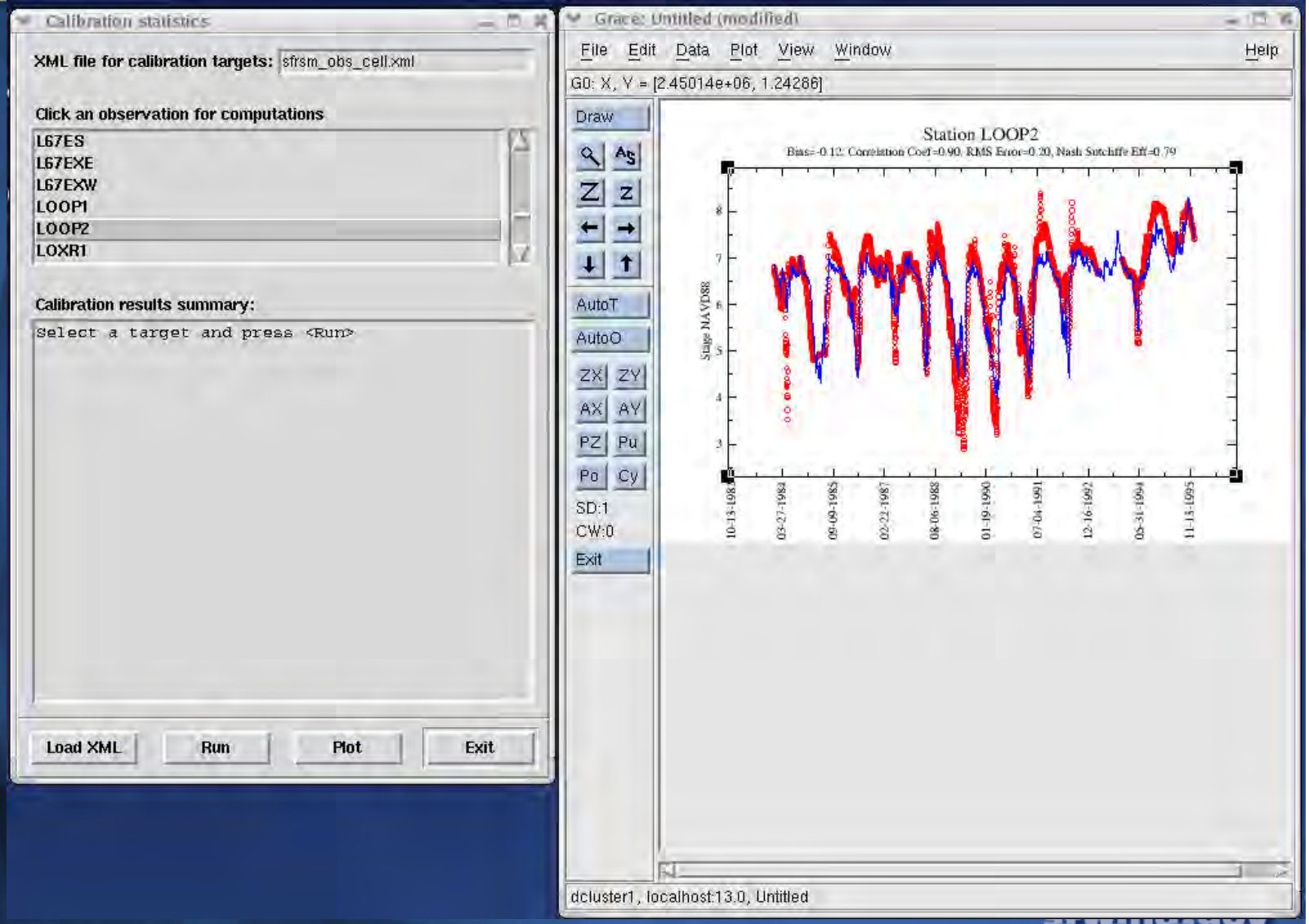
RSM Results Viewer



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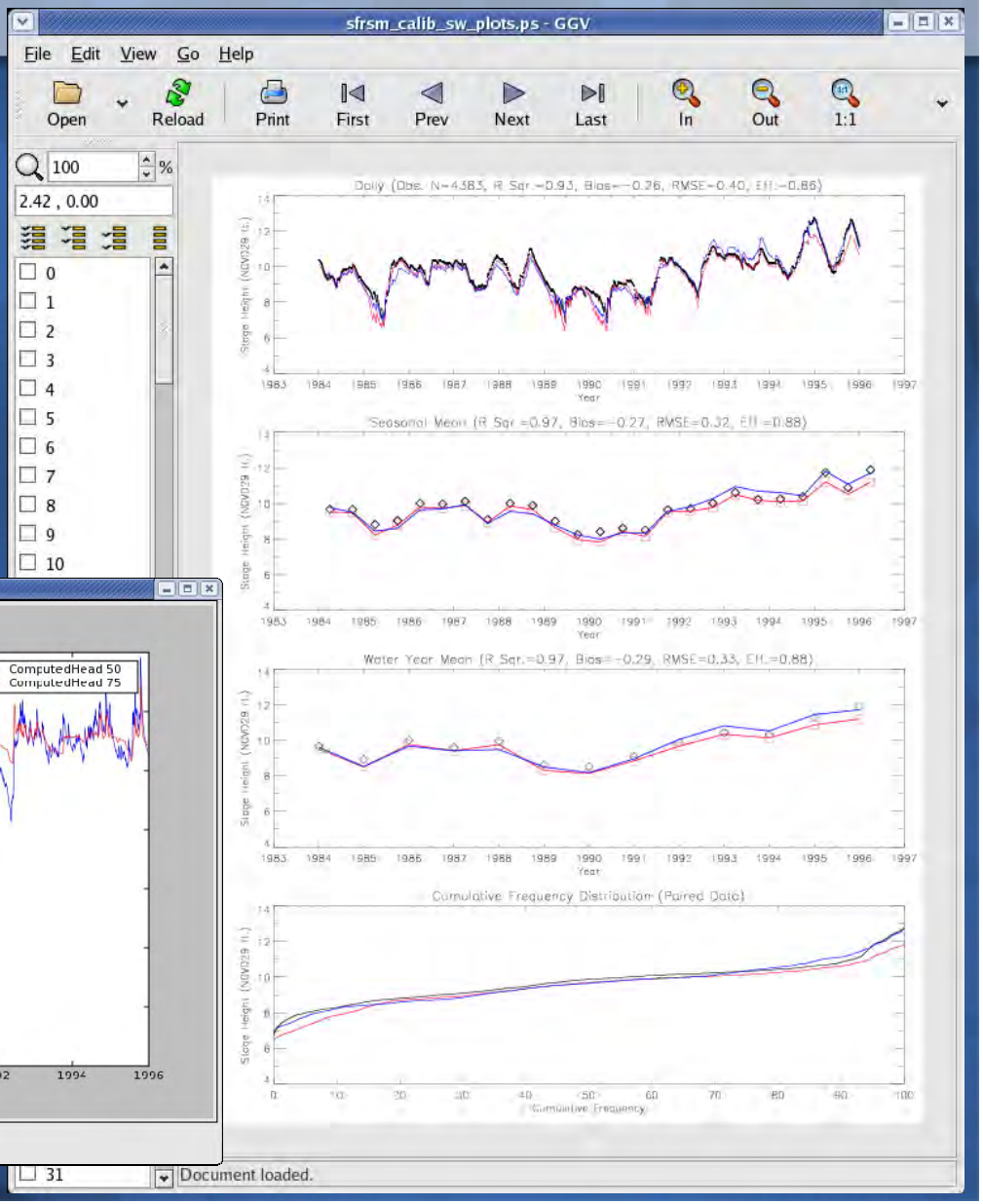
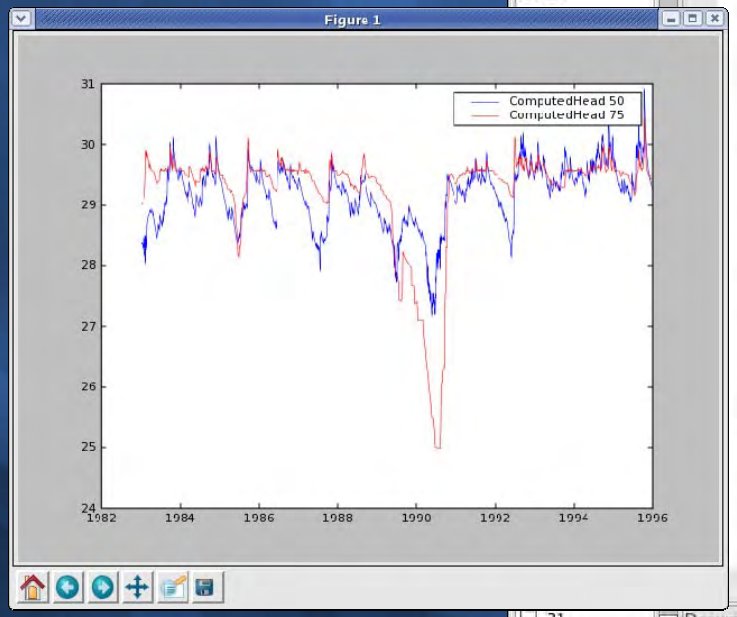
RSM Results Viewer

Calibration Statistics Output

- Stats from netCDF output
  - graphically displayed using IDL Virtual Machine
  - IDLVM is a freely distributable application that runs under windows or Linux





Hydrographs displayed for selected timestep

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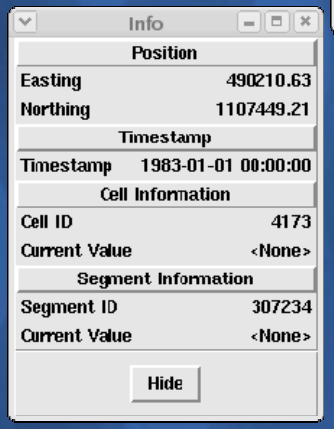
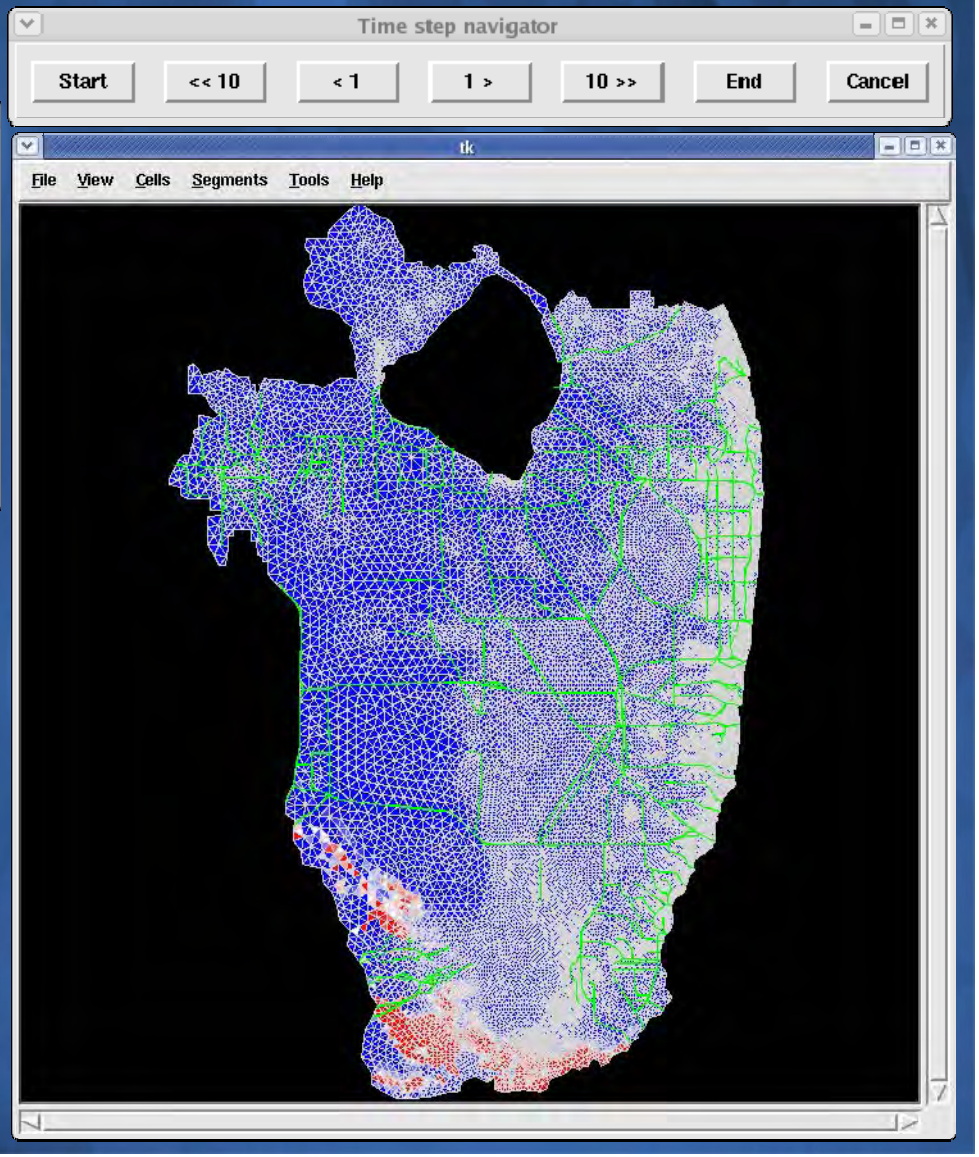
RSM Results Viewer





Computehead Cell Color Floods

Color floods and timestep animation movies help visualize output from the model

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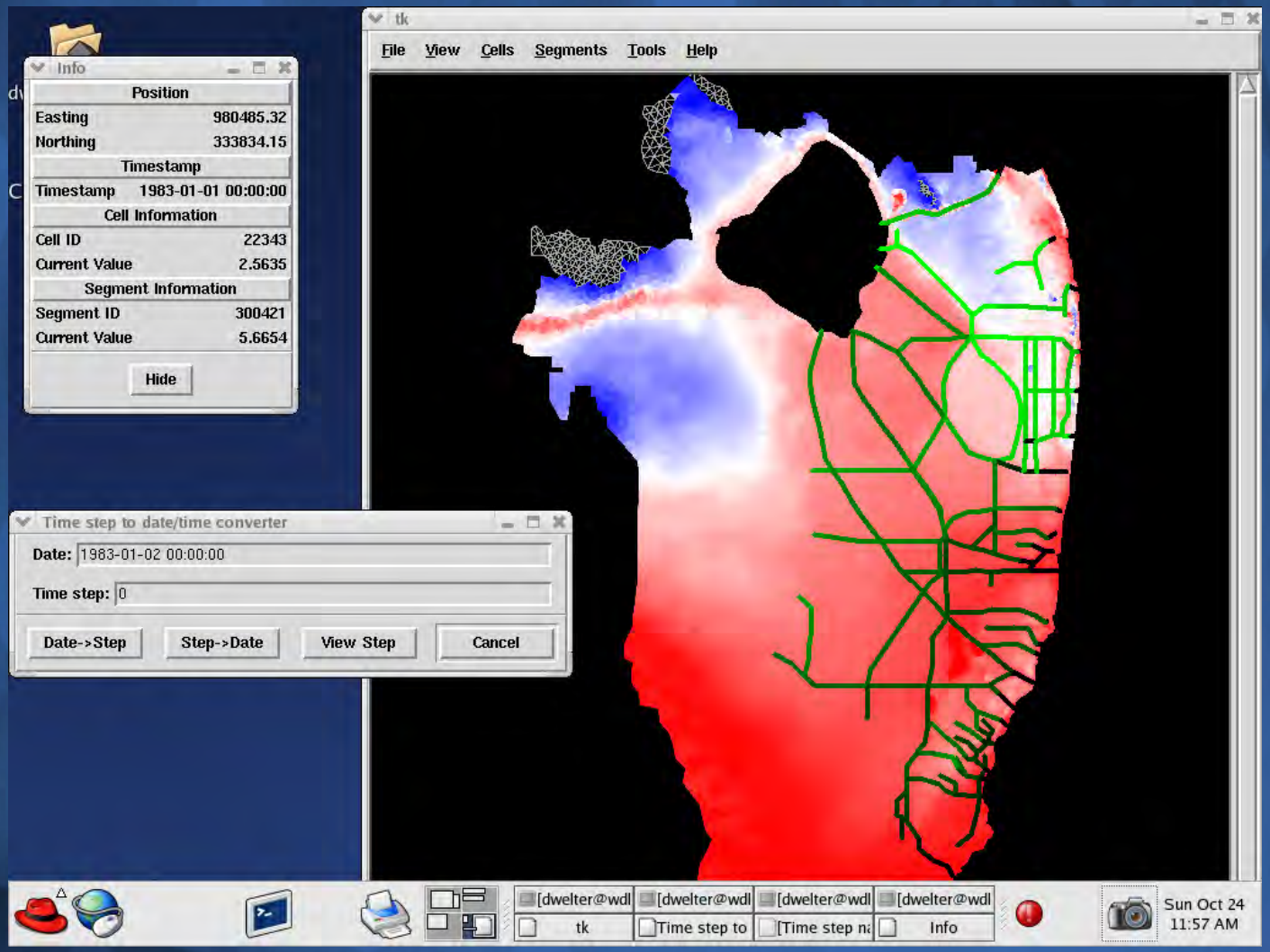
RSM Results Viewer



Conclusion

Addressed peer review goals related to appropriate use of model and suitability for client needs:

- Showed appropriate assumptions
- Outlined calibration approach
- Building on lessons learned
- Aware of client needs and managing client expectations
- Developing tools to better meet our own and client needs